AIRBORNE ASBESTOS CONCENTRATIONS THREE YEARS AFTER ABATEMENT IN SEVENTEEN SCHOOLS

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FOREWORD

Today's rapidly developing and changing technologies and industrial products and practices frequently carry with them the increased generation of materials that, if improperly dealt with, can threaten both public health and the environment. The U.S. Environmental Protection Agency (EPA) is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. These laws direct the EPA to perform research to define our environmental problems, to measure the impacts, and to search for solutions.

The Risk Reduction Engineering Laboratory is responsible for planning, implementing, and managing research, development, and demonstration programs to provide an authoritative, defensible, engineering basis in support of the policies, programs, and regulations of the EPA with respect to drinking water, wastewater, pesticides, toxic substances, solid and hazardous wastes, and Superfund-related activities. This publication is one of the products of that research and provides a vital communication link between the researcher and the user community.

This report provides information on airborne asbestos concentrations measured three years after asbestos abatement at 17 schools in New Jersey. Air monitoring was conducted to determine the effectiveness of the asbestos control programs in these schools.

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ABSTRACT

From 1988 through 1991, the U.S. Environmental Protection Agency's Risk Reduction Engineering Laboratory and the New Jersey Department of Health's Environmental Health Service conducted air monitoring in 17 schools in New Jersey to determine the effectiveness of their asbestos control programs.

In 1988, a study was conducted to document Asbestos Hazard Emergency Response Act final clearance concentrations of asbestos at these 17 schools. The findings of this study prompted a follow-up study in 1990 to determine the airborne asbestos concentrations 2 years after the abatement efforts in these schools. Although the data from the 1990 study provided information regarding airborne asbestos levels during simulated occupancy conditions 2 years after abatement, whether these data were representative of levels during actual occupancy was equivocal.

Another follow-up study was conducted in May 1991 to determine the airborne asbestos concentrations in these 17 schools during actual occupied conditions. Results showed elevated levels of airborne asbestos at seven of the schools. Reentrainment of residual asbestos-containing debris from the 1988 abatement or operations and maintenance activities may have contributed to the elevated airborne asbestos concentrations measured during the May 1991 study.

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SECTION 1

INTRODUCTION

The ultimate goal of every asbestos abatement project is to eliminate or reduce, to the extent possible, the actual or potential hazard presented by airborne asbestos structures. From 1988 through 1991, the Risk Reduction Engineering Laboratory (RREL) of the U.S. Environmental Protection Agency (EPA) and the Environmental Health Service (EHS) of the New Jersey Department of Health (NJDOH) conducted a series of studies to determine the effectiveness of asbestos control programs in 17 schools in New Jersey.[1,2]

Background

In 1988, the EPA-RREL and NJDOH-EHS conducted a study to document Asbestos Hazard Emergency Response Act (AHERA) clearance air-sampling practices and final clearance concentrations of airborne asbestos at 20 abatement projects in 17 New Jersey schools.[1] The results of the study prompted a follow-up study in 1990 (Phase II) to determine the airborne asbestos concentrations in these 17 schools 2 years after abatement.[2] Although the data from the 1990 study provided information regarding airborne asbestos levels under simulated occupancy conditions, whether the data were representative of conditions during actual occupancy remained equivocal. Therefore, an additional follow-up study was conducted in May 1991 (Phase III) to determine the airborne asbestos levels during actual occupied conditions 3 years after abatement in these same schools.

The purpose of this research study was to measure airborne asbestos concentrations during occupied conditions at the seventeen schools that underwent asbestos abatements in 1988. The seventeen schools were not a statistical random sample and were initially selected based largely on availability. Furthermore, the seventeen schools were likely to differ in their abatement history and status with

respect to the presence of asbestos-containing material. Therefore, a site-by-site evaluation was performed. There was no consideration given to combining data across all sites to reach a general conclusion.

Objectives

The objectives of this study were as follows:

- To determine the airborne asbestos levels measured under occupied conditions in 17 schools that underwent abatement in 1988.
- To determine whether the airborne asbestos levels measured under occupied conditions in 1991 were significantly different than those measured outdoors.
- To determine whether the airborne asbestos concentrations measured in 1991 were significantly different from the AHERA clearance concentrations measured in 1988.
- To determine whether the airborne asbestos concentrations measured under occupied conditions in 1991 were significantly different from those measured under simulated occupancy conditions in 1990.

SECTION 2

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The following are the principal conclusions reached during this study:

- Seven of the 20 sites (five of the 17 schools) sampled under occupied conditions in 1991 showed significantly higher airborne asbestos concentrations in the previously abated area and/or the perimeter area than those existing outdoors. Differences in mean concentrations between those measured inside the schools and those existing outdoors were not statistically significant at the other 13 sites.

- Eight of the 20 sites showed average airborne asbestos concentrations above the AHERA initial screening criterion of 70 structures per square millimeter. Visual inspections conducted by the New Jersey Department of Health indicated that reentrainment of residual asbestos-containing debris from the 1988 abatement or operations and maintenance activities may have contributed to the elevated asbestos concentrations measured in these schools.

- Visual inspections conducted by the New Jersey Department of Health at 10 of the 20 sites showed that 6 sites had at least one asbestos-containing material (ACM) that was not identified in the Asbestos Management Plan. At one of these six sites, the Asbestos Management Plan was in error regarding the identification, location, and condition of ACM.

- Three of the 20 sites showed significantly higher airborne asbestos concentrations in the previously abated area and/or the perimeter area in 1991 than those measured in 1988. Conversely, 9 of the 20 sites showed significantly lower airborne asbestos concentrations in the previously abated area and/or perimeter areas in 1991 than those measured in 1988. Differences between mean concentrations measured in 1988 and 1991 at the other 8 sites were not statistically significant.

- The mean airborne asbestos concentrations measured in the previously abated area and/or the perimeter area at 7 of the 20 sites during

occupied conditions in 1991 were significantly greater than those measured under simulated occupancy conditions in 1990. Conversely, one site showed significantly lower concentrations during occupied conditions than during simulated occupancy. Differences in mean concentrations measured in 1990 and 1991 at the other 12 sites were not statistically significant.

Recommendations

Follow-up air monitoring should be conducted at these sites to determine if elevated post-abatement airborne concentrations of asbestos is continuing at these schools. The follow-up air monitoring should be coupled with detailed visual inspections to determine the sources of the asbestos and to identify appropriate remedial measures. The results of the follow-up study will provide information regarding the long-term effectiveness of asbestos control programs. This information may assist EPA in evaluating the need for issuance of guidance on asbestos management practices.

SECTION 3

STUDY DESIGN AND METHODS

This study was conducted at the same 17 schools involved in the 1988 EPA-RREL/NJDOH-EHS study, which documented Asbestos Hazard Emergency Response Act (AHERA) air monitoring practices and final clearance concentrations of airborne asbestos,[1] and in the 1990 EPA-RREL/NJDOH-EHS study, which measured airborne asbestos concentrations 2 years after abatement.[2]

The 17 schools involved 20 abatement sites. Access to each school was coordinated directly by NJDOH-EHS. Area airborne asbestos concentrations were measured at each site in the same three areas as in the previous studies: 1) the previously abated area, 2) the perimeter area (outside the abated area but inside the building), and 3) outdoors. The actual abatement and perimeter areas could not be separated because the containment barriers present during the 1988 abatement had been removed. Also recognized was the fact that, in the interim since 1988, other sources (e.g., routine maintenance of asbestos-containing resilient floor tile or other operations and maintenance activities) may have contributed to the current concentrations of airborne asbestos.

Air Sampling Strategy

The air sampling strategy for the study consisted of monitoring during periods of occupancy at all sites. In consideration of the resulting data, follow-up sampling was conducted using a modified aggressive protocol at sites with average airborne asbestos concentrations above 0.02 s/cm^2. This follow-up monitoring was performed to both 1) determine the need for response actions and 2) determine the completion of the response actions. Table 1 summarizes the air sampling strategy.

TABLE 1. SUMMARY OF AIR SAMPLING STRATEGY

Phase	Period	No. of Sites	Type of Sampling	Criteria
III	May 1991	20	Occupied Conditions	All sites monitored to determine levels
IIIa	Early August 1991	10	Modified Aggressive	8 sites - Average asbestos concentration >0.02 s/cm^3 (70 s/mm^2) 2 sites - in same schools as one of the eight above
IIIb	Late August 1991	4	Modified Aggressive	Following response action to attain <0.02 s/cm^3
IIIc	September 1991	1	Modified Aggressive	Following additional response action to attain <0.02 s/cm^3

Phase III - May 1991

At each site, five area air samples were collected in each of three areas: 1) the previously abated work area, 2) the perimeter area (outside the previously abated work area but inside the building), and 3) outdoors. Table 2 shows the number of air samples collected at each site. The air samples were collected at approximately the same locations as those collected during the 1988 and 1990 studies. In addition to the area air samples, three quality assurance samples (one closed and two open field blanks) were collected at each school.

The samples were collected during periods of occupancy (i.e., during school hours, 8:00 am to 3:00 pm). Because certain sampling situations (e.g., inside a classroom) could not tolerate noise from an electrically powered sampling pump, the pumps were placed in special acoustical cases designed to attenuate the noise of the sampling pump to a sound pressure level of <40 dB (RE 20 N/m^2) at a distance of 3 ft. A noise level of 40 dB is rated as "quiet" for private offices and conference rooms.[3]

Phase III Follow-up - Summer 1991

Follow-up air sampling in the previously abated work area and the perimeter area was conducted during unoccupied conditions in accordance with a modified

aggressive sampling protocol designed to simulate normal building activity. The protocol involved sweeping only the floors with the exhaust of a 1-hp leaf blower at a

TABLE 2. NUMBER OF AREA AIR SAMPLES COLLECTED AT EACH SITE DURING OCCUPIED CONDITIONS IN MAY 1991

Site	Number of samples and location		
	Previously abated area	Perimeter	Outdoors
A	5	5	5
B	5	5	5
C	5	5	5
D	5	5	5
E	5	5	5
F	5	5	5
G	5	5	5
H	5	5	5
I	5	5	5
J	5	5	5
K	5	5	5
L	5	5	5
M	5	5	(5)[a]
N	5	5	(5)[b]
O	5	5	5
P	5	5	5
Q	5	(5)[c]	(5)[c]
R	5	5	5
S	5	5	5
T	5	5	5
Total samples	100	95	85

[a] Same samples as collected at Site C (i.e., Site M was the second abatement project at this school).
[b] Same samples as collected at Site K (i.e., Site N was the second abatement project at this school).
[c] Same samples as collected at Site B (i.e., Site Q was the second abatement project at this school).

rate of 5 minutes per 1,000 ft^2 of floor space. One stationary fan (18-in. diameter, axial flow) per 10,000 ft^3 was positioned with the air directed toward the ceiling to maintain air movement during sampling.

Phase IIIa - Early August 1991

Follow-up air monitoring was conducted in August 1991 at 10 of the 20 sites (Sites B, D-H, K, M ,N, and Q). Sites B, D-G, K and M were selected because the average airborne asbestos concentration in the previously abated area and/or perimeter area exceeded 0.02 s/cm^3. Sites N and Q were also monitored because these sites were in the same schools as sites K and B, respectively, which had levels exceeding 0.02 s/cm^3. Site H was monitored because replicate analyses of selected samples at this site showed average levels above 0.02 s/cm^3 (derived from the AHERA initial screening criteria of 70 s/mm^2-40 CFR 763). At each of the 10 sites, five area air samples were collected in the same three areas as the samples collected during occupied conditions in May 1991: 1) the previously abated work area, 2) the perimeter area, and 3) outdoors. Three quality assurance samples (one closed and two open field blanks) also were collected at each school.

Phase IIIb - Late August 1991

Based on the results of the Phase IIIa monitoring, four schools (Sites F, G, H, and M) were required to conduct response actions (i.e., cleaning) in the previously abated area and/or perimeter area to reduce residual airborne asbestos contamination. Subsequent to these response actions, additional area air samples were collected in the affected areas at these sites. At each of the four sites, five area air samples were collected in the same areas as the Phase III and Phase IIIa samples (no outdoor samples were collected at Site M). Three quality assurance samples (one closed and two open blanks) also were collected at each school.

Phase IIIc - September 1991

Airborne asbestos concentrations at Site M were still elevated after the Phase IIIb monitoring. Therefore, the previously abated area and the perimeter area

response actions were again conducted, and additional samples were collected. Five samples were collected in the previously abated area and five were collected in the perimeter area. One closed and two open field blanks were also collected.

Previous Air Monitoring Strategies

Samples collected previously in 1988 were collected during the AHERA clearance phase of the abatement. In the abatement work area, samples were collected under the sampling conditions that existed during the final-clearance air sampling. The perimeter area samples were collected under static conditions.

Samples collected previously in 1990 were collected in accordance with modified aggressive sampling protocol designed to simulate normal building activity. The protocol involved sweeping only the floors with the exhaust of a 1-hp leaf blower and positioning one stationary fan per 10,000 ft^3 with the air directed toward the ceiling to maintain air movement during sampling. The air samples were collected at approximately the same locations as those collected in 1988.

Site Documentation

For each of the 17 schools monitored in May 1991, the NJDOH-EHS documented the history of the abatement activities between 1988 and 1991 and operations and maintenance (O&M) activities on any remaining asbestos-containing building material (ACBM) in the previously abated area and perimeter area. This information was obtained from abatement notices required under the New Jersey Administrative Codes (N.J.A.C. 8:60-7 and N.J.A.C. 12:120-7), AHERA Asbestos Management Plans, and information provided by the designated person and/or school officials who were interviewed.

NJDOH Visual Inspection

Subsequent to conducting the follow-up air monitoring at the eight schools in August 1991 (Phase IIIa), a certified AHERA building inspector from NJDOH-EHS conducted a visual inspection at each of these schools.

Prior to conducting the inspection, the inspector reviewed each school's Asbestos Management Plan. The review included 1) recording the material category (e.g., thermal system insulation), amount of material (e.g., linear feet), and condition of material (e.g., damaged thermal system insulation) for the ACBM remaining in the previously abated area and perimeter area; 2) recording completed response actions (including O&M); and 3) recording any renovations that had occurred.

The visual inspection was not intended to be a comprehensive assessment of the ACBM in the school; rather, it was designed to focus on the areas monitored (i.e., previously abated areas and perimeter areas) in an attempt to locate the possible sources of the airborne asbestos contamination measured in May 1991. The inspection included identification and condition of ACBM not recorded in the Management Plan as well as the condition of the ACBM recorded in the Management Plan, and the documentation of the presence of asbestos-containing dust and debris located in the areas monitored.

Sampling Methods

Fixed-Station Area Air Samples

Air samples were collected on open-face, 25-mm-diameter, 0.45-µm-pore-size, mixed cellulose ester (MCE) membrane filters with a 5-µm-pore-size, MCE, backup diffusing filter and cellulose support pad contained in a three-piece cassette. The filter cassettes were positioned approximately 5 feet above the floor on tripods, with the filter face at approximately a 45-degree angle toward the floor. The filter assembly was attached to a 1/6-hp electrically powered vacuum pump operating at a flow rate of approximately 9 L/min. Air volumes ranged from 943 to 2536 L. At the end of the sampling period, the filters were turned upright before being disconnected from the vacuum pump; they were then stored in this position. The sampling pumps were calibrated with a calibrated precision rotameter both immediately before and after sampling.

Bulk Samples

Bulk samples of suspect ACBM (e.g., thermal system insulation, fireproofing, and resilient floor tile) or debris were collected by the NJDOH inspector for laboratory analysis to determine the asbestos content. The samples were collected by either a standard coring tool or the collection of debris. Both types of samples were placed in labeled containers.

Analytical Methods

Air Samples

The MCE filters were prepared and analyzed in accordance with the nonmandatory transmission electron microscopy (TEM) method, as described in the AHERA final rule (40 CFR 763). A sufficient number of grid openings were analyzed for each sample to ensure a sensitivity (the concentration represented by a single structure) of no greater than 0.005 asbestos structure per cubic centimeter (s/cm^3) of air sampled. In addition to the requirements of the nonmandatory TEM method, the specific length and width of each structure were measured and recorded. The samples were prepared and analyzed by U.S. EPA's TEM laboratory in Cincinnati, Ohio.

Bulk Samples

The type and percentage of asbestos in the bulk samples were determined by polarized light microscopy (PLM) and X-ray diffraction (XRD). The samples were prepared and analyzed in accordance with the "Interim Method for Determination of Asbestos in Bulk Insulation Samples" (EPA 600/M4-82-020). The samples were prepared and analyzed by the NJDOH's Public Health and Environmental Laboratories in Trenton, New Jersey.

Statistical Methods

All estimated concentrations were based on the number of asbestos structures counted. If no asbestos structures were counted in a sample, that sample was

assigned an estimated concentration of 0 s/cm^3. Results of the quality assurance sample analyses were not included in the statistical analysis of these data.

Airborne asbestos concentrations measured in each of the three sampling locations were characterized by the use of descriptive statistics. Because the 20 sites were likely to differ in their abatement history and status with respect to the presence of asbestos-containing material, each site was considered separately. The descriptive statistics included the arithmetic mean, minimum and maximum concentrations, and sample size.

A single-factor analysis of variance (ANOVA) was used to examine differences between concentrations measured in the previously abated work area, perimeter area, and outdoors in 1991. Each site was evaluated separately. When overall differences were detected among the three sampling locations, the Tukey multiple comparison procedure was used to evaluate the pairwise differences. A single-factor ANOVA analysis was also used to compare airborne asbestos concentrations measured in 1988, 1990, and 1991. Each sampling location was considered separately. The transformation $\ln(x + 0.002)$, where x is the measured airborne asbestos concentration, was applied to each measurement before the ANOVA or t-test was performed. The transformation was used to make variances more equal and to provide data that are better approximated by a normal distribution. The constant 0.002, a value chosen to be smaller than the majority of analytical sensitivities, was used because some zero values were present (the natural logarithm of zero is undefined). The transformation was used only for the ANOVA analysis; it was not used for any other part of the data analysis (e.g., plots or descriptive statistics). All statistical comparisons were performed at the 0.05 level of significance. Any reference in this report to a "significant" difference between mean concentrations implies that the difference is statistically significant.

SECTION 4

QUALITY ASSURANCE

Sample Chain of Custody

During the study, sample chain-of-custody procedures were an integral part of both the sampling and analytical activities and were followed for all air and bulk samples collected. The field custody procedures documented each sample from the time of its collection until its receipt by the analytical laboratory. Internal laboratory records then documented the custody of the sample through its final disposition.

Standard sample chain-of-custody procedures were used. Each air sample was labeled with a unique project identification number, which was recorded on a sample data sheet along with other information, such as sampling date, location of the sampler, sampling flow rate, sampling start/stop time, and conditions of sampling.

Sample Analysis

Specific quality assurance procedures outlined in the AHERA rule were used to ensure the precision of the collection and analysis of air samples, including filter lot blanks, open and closed field blanks, and repeated sample analyses.

Filter lot blanks, which are samples selected at random from the lot of filters used in this study, were analyzed to determine background asbestos contamination on the filters. Five percent (50 filters) of the total number of filters (2000 filters) from the lot used in this research study were analyzed by the EPA-RREL TEM laboratory. The filters were prepared and analyzed in accordance with the nonmandatory AHERA TEM method. The TEM analysis of the 50 MCE filters showed a background contamination level of 0 asbestos structures per 10 grid openings on each filter.

Open field blanks are filter cassettes that have been transported to the sampling site, opened for a short time (<30 sec) without air having passed through the

filter, and then sent to the laboratory. Closed field blanks are filter cassettes that have been transported to the sampling site and sent to the laboratory without being opened. Two open and one closed field blank were collected at each site. Ten grid openings were examined on each filter. One asbestos structure was detected on an open field blank and on a closed field blank.

The reproducibility and precision of the TEM analyses were determined by an evaluation of repeated analyses of randomly selected samples. Repeated analyses included replicate and duplicate analyses. A replicate analysis of 16 samples was performed to assess the uniformity of the distribution of asbestos structures on a single grid preparation. A replicate analysis is a second analysis of the same grid performed by the same microscopist as the original analysis. The microscopist uses the same grid preparation but counts different grid openings from those originally read. The results of the replicate analyses are shown in Table 3.

A duplicate sample analysis of six samples was performed to assess the reproducibility of the TEM analysis and to quantify any analytical variability resulting from the filter preparation procedure. A duplicate analysis is the analysis of a second TEM grid prepared from a different area of the sample filter but analyzed by the same microscopist who performed the original analysis. The results of the duplicate analyses are shown in Table 4.

The coefficient of variation (CV) for the replicate and duplicate analyses was estimated by assuming a lognormal distribution for the data on the original scale and estimating the variance on the log scale. The variance was estimated by the mean square error obtained from a one-way ANOVA of the log-transformed data with the sample identification number as the main factor. The transformation $\ln(x + 0.002)$, where x is the measured airborne asbestos concentration, was applied to each measurement before the ANOVA was performed. The constant 0.002, a value chosen to be smaller than the minimum analytical sensitivity, was used because many zero values were present. The CVs associated with the replicate and duplicate analyses were 135 and 42 percent, respectively.

TABLE 3. DATA SUMMARY FOR REPLICATE ANALYSES[a]

Sample number	Original analysis		Replicate analysis	
	N[b]	s/cm^3	N[b]	s/cm^3
A91-09-P	0	0	1	0.003
D91-13-A	2	0.006	4	0.014
F91-11-A	10	0.035	8	0.028
H91-11-A	5	0.014	1	0.003
H91-12-A	1	0.003	5	0.015
H91-13-A	0	0	33, 3[c]	0.102, 0.009[c]
H91-14-A	1	0.003	1	0.003
H91-15-A	0	0	8	0.025
I-91-01-O	0	0	0	0
L91-07-P	2	0.006	0	0
N91-08-P	1	0.003	0	0
O91-07-P	0	0	0	0
P91-09-P	0	0	1	0.004
R91-13-A	1	0.003	1	0.003
S91-11-A	0	0	2	0.008
T91-15-A	2	0.007	0	0

[a] Different grid openings from the same grid preparation were counted by the same microscopist.
[b] Number of asbestos structures.
[c] Two replicate analyses were performed on this sample.

TABLE 4. DATA SUMMARY FOR DUPLICATE ANALYSES[a]

Sample number	Original analysis		Duplicate analysis	
	N[b]	s/cm^3	N[b]	s/cm^3
F91-12-A	10	0.066	8	0.038
F91-09-P	7	0.025	2	0.007
F91-10-P	15	0.054	13	0.047
H91-02-O	1	0.003	0	0
J91-15-A	0	0	0	0
O91-11-A	7	0.022	3	0.010
T91-05-O	0	0	0	0

[a] A second TEM grid preparation was analyzed by the same microscopist.
[b] Number of asbestos structures.

Counts from the original sample analysis were also compared to the counts from the corresponding replicate or duplicate sample analyses according to the methods specified in the original Yamate air method,[4] the Asbestos Hazard Emergency Response Act (AHERA) Final Rule (40 CFR Part 763),[5] and the original QA guidelines from the EPA "Gold Book."[6] The Yamate method calculates a 95 percent confidence interval for the observed number of asbestos structures on a sample, assuming a Poisson distribution. If the counts for the replicate and/or duplicate fall within the 95 percent confidence interval, then there is no statistically significant difference between the counts. Only four samples exhibited statistically significant differences between the original and replicate counts (H91-11-A, H91-12-A, H91-13-A and H91-15-A). All four samples were from the same school and were selected for replicate analysis because the original samples showed an uneven distribution of counts from one grid opening to the next. Although the duplicate counts were consistently lower than the original analyses, none of the differences were statistically significant.

SECTION 5

RESULTS AND DISCUSSION

Site Descriptions

Table 5 presents the post-1988 abatement history and the remaining ACBM at the 20 sites. Post-1988 abatement occurred at 1 of the 20 sites (Site O) in the previously abated area and 4 of the 20 sites (Sites A, D, L, and N) in the perimeter area. At 15 sites, ACBM is still present in the previously abated areas; at all of the sites, ACBM is still present in the perimeter areas.

Airborne Asbestos Levels During Occupied Conditions in May 1991

Table 6 presents the mean, minimum, and maximum airborne asbestos concentrations measured at each of the 20 sites in the 17 schools. Figures 1 and 2 illustrate the average airborne asbestos concentrations in the previously abated and perimeter areas, respectively. Figures 3 and 4 illustrate the average concentration of asbestos structures per square millimeter (s/mm^2) of filter in the previously abated area and perimeter area, respectively, at each of the 20 sites. Eight of the 20 sites showed levels above the AHERA initial screening criterion of 70 s/mm^2 (40 CFR 763) and above 0.02 s/cm^3 (NJDOH clearance criteria). Individual measurements of the airborne asbestos concentrations at each of the 20 sites are presented in Appendix A.

Individual single-factor ANOVAs were used to compare mean concentrations measured in each of the three sampling locations at each site. The results of the ANOVA analyses, along with the results from the Tukey multiple comparison procedure, are presented separately for each site in Table 7. The remaining subsections summarize the pairwise comparisons between mean concentrations in the three sampling locations.

TABLE 5. POST-1988 ABATEMENT HISTORY AND REMAINING ASBESTOS-CONTAINING BUILDING MATERIAL (ACBM) AT THE 20 SITES

Site	Abatement after 1988			Remaining ACBM[a]	
	Abatement area	Perimeter area	Material abated[a]	Abatement area	Perimeter area
A	No	Yes	AP, TSI	FT	FT
B	No	No	-	FT, AP	FT, TSI
C	No	No	-	P (<1%)[b]	P (<1%)
D	No	Yes	TSI	TSI	TSI, FT
E	No	No	-	FT, TSI	FT
F	No	No	-	TSI	FT, TSI
G	No	No	-	None	FT, P (<1%)
H	No	No	-	AP, TSI	FT, AP
I	No	No	-	None	FT
J	No	No	-	TSI	FT
K	No	No	-	None	FT, TSI
L	No	Yes	FT, TR	FT, TR	FT
M	No	No	-	P (<1%)	P (<1%)
N	No	Yes	AP	None	FT, TSI
O	Yes	No	TSI	TR	FT
P	No	No	-	FT	FT
Q	No	No	-	FT, AP	FT, TSI
R	No	No	-	FT	FT
S	No	No	-	FT	FT
T	No	No	-	None	FT,CT

[a] AP = Acoustical Plaster
TSI = Thermal System Insulation
FT = Floor Tile
TR = Transite
CT = Ceiling Tile
P = Wall Plaster

[b] Asbestos is present at a concentration of less than 1 percent

TABLE 6. AIRBORNE ASBESTOS CONCENTRATIONS MEASURED DURING PERIODS OF OCCUPANCY AT SEVENTEEN SCHOOLS IN MAY 1991

Site	Previously abated area			Perimeter area			Outdoors		
	Asbestos concentration, s/cm^3 (N=5)			Asbestos concentration, s/cm^3 (N=5)			Asbestos concentration, s/cm^3 (N=5)		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum
A	0.001	0	0.003	0.003	0	0.008	0.003	0	0.005
B	0.027	0.01	0.055	0.012	0.004	0.024	0.001	0	0.004
C	0.005	0	0.012	0.001	0	0.003	0.003	0	0.007
D	0.020	0.003	0.059	0.004	0	0.009	0.004	0	0.012
E	0.037	0.011	0.069	0.010	0	0.029	0.003	0	0.007
F	0.043	0.032	0.066	0.036	0.010	0.058	0.001	0	0.002
G	0.027	0.011	0.037	0.005	0	0.011	0.001	0	0.004
H	0.004	0	0.014	0.005	0	0.011	0.003	0	0.006
I	0.004	0	0.007	0.005	0	0.011	0.005	0	0.020
J	0.003	0	0.011	0	0	0	0.001	0	0.004
K	0.041	0.014	0.097	0.003	0	0.007	0	0	0
L	0.006	0	0.016	0.003	0	0.006	0	0	0
M[a]	0.023	0	0.056	0.004	0	0.007	0.003	0	0.007
N[b]	0.004	0.003	0.009	0.015[c]	0	0.046	0	0	0
O	0.005	0	0.022	0	0	0	0.001	0	0.003
P	0.004	0	0.011	0.001	0	0.004	0	0	0
Q[d]	0.009	0	0.018	0.012	0.004	0.024	0.001	0	0.004
R	0.005	0	0.010	0.001	0	0.004	0.004	0	0.012
S	0.001	0	0.004	0.003	0	0.011	0.001	0	0.004
T	0.001	0	0.007	0.001	0	0.004	0	0	0

[a] Outdoor samples are the same as those collected at Site C (i.e., Site M was the second abatement project at this site).
[b] Outdoor samples are the same as those collected at Site K (i.e., Site N was the second abatement project at this site).
[c] N = 4.
[d] Perimeter and outdoor samples are the same as those collected at Site B (i.e., Site Q was the second abatement project at this school).

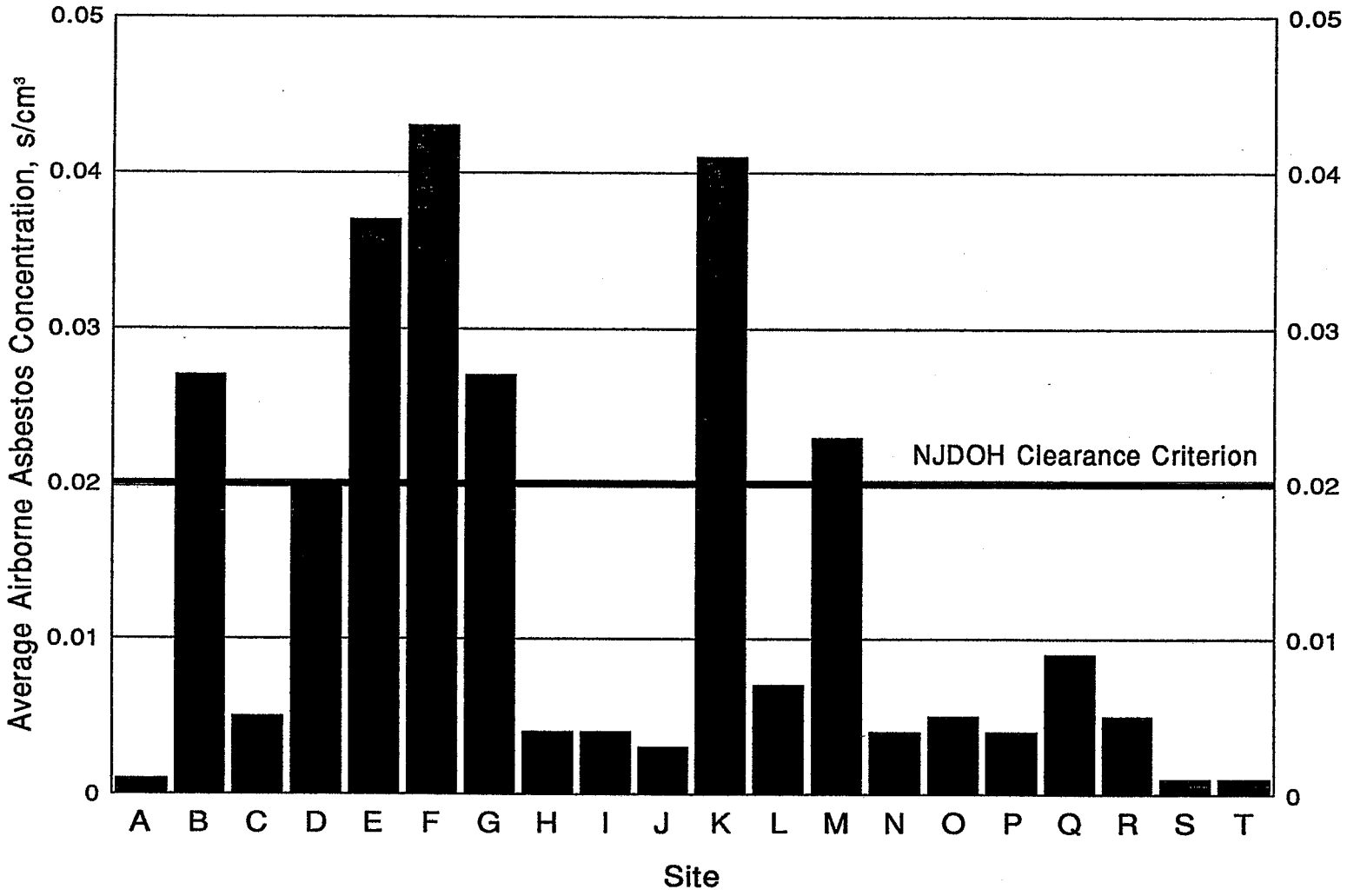

Figure 1. Average airborne asbestos concentrations (s/cm³) in the previously abated area measured during occupied conditions in May 1991.

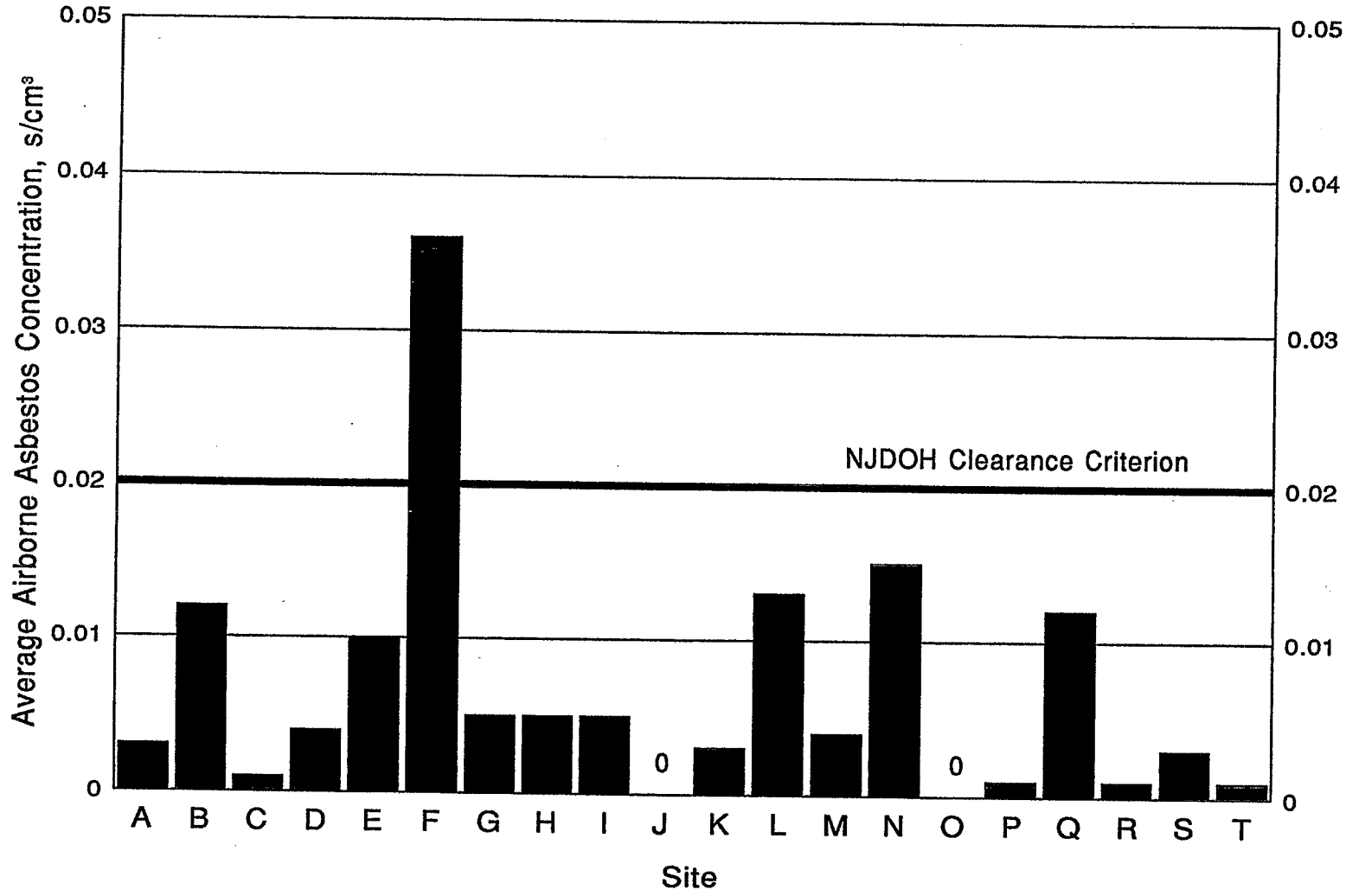

Figure 2. Average airborne asbestos concentrations (s/cm³) in the perimeter area measured during occupied conditions in May 1991.

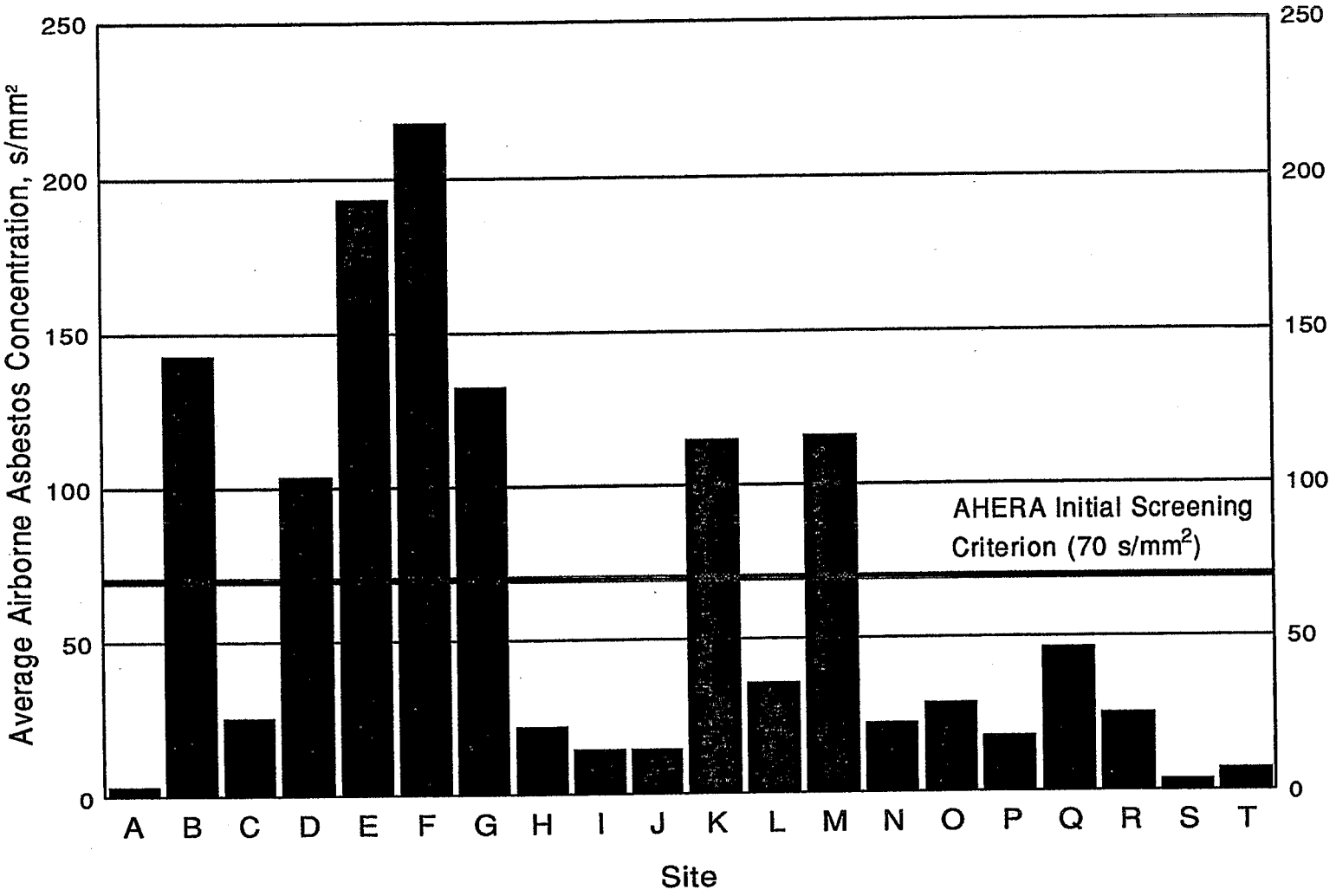

Figure 3. Average concentrations of asbestos structures per square millimeter (s/mm²) in the previously abated area measured during occupied conditions in May 1991.

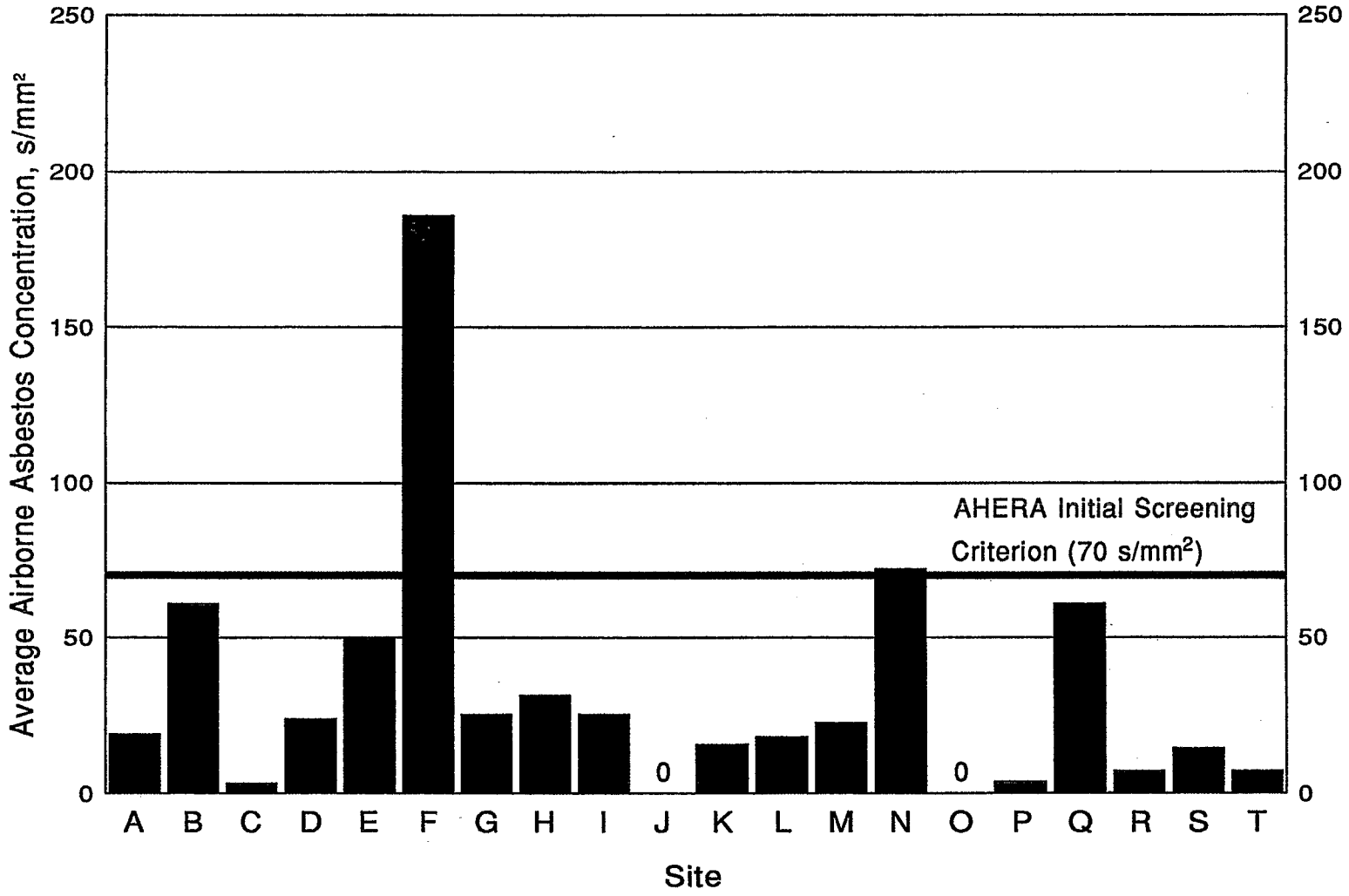

Figure 4. Average concentration of asbestos structures per square millimeter (s/mm²) in the perimeter area measured during occupied conditions in May 1991.

TABLE 7. SUMMARY OF ANOVA RESULTS FOR AIRBORNE ASBESTOS CONCENTRATIONS DURING OCCUPIED CONDITIONS IN 1991

Site	ANOVA p-Value[a]	Statistically significant differences in mean airborne asbestos concentration[b,c,d]
A	0.1665	P(0.003) O(0.003) A(0.001)
B	0.0002	A(0.027) P(0.012) O(0.001)
C	0.8823	A(0.005) O(0.003) P(0.001)
D	0.0899	A(0.020) P(0.004) O(0.004)
E	0.0069	A(0.037) P(0.010) O(0.003)
F	0.0001	A(0.043) P(0.036) O(0.001)
G	0.0005	A(0.027) P(0.005) O(0.001)
H	0.8699	P(0.005) A(0.004) O(0.003)
I	0.6961	P(0.005) O(0.005) A(0.004)
J	0.2878	A(0.003) O(0.001) P(0)
K	0.0001	A(0.041) P(0.003) O(0)
L	0.0752	A(0.006) P(0.003) O(0)
M	0.1924	A(0.023) P(0.004) O(0.003)
N	0.0125	P(0.015) A(0.004) O(0)
O	0.2345	A(0.005) O(0.001) P(0)
P	0.0891	A(0.004) P(0.001) O(0)
Q	0.0059	P(0.012) A(0.009) O(0.001)
R	0.3899	A(0.005) O(0.004) P(0.001)
S	0.5776	P(0.003) A(0.001) O(0.001)
T	0.4214	A(0.001) P(0.001) O(0)

[a] If the ANOVA p-value was less than 0.05, then the Tukey multiple comparison procedure was used to distinguish pairwise differences between sampling locations.

[b] A = previously abated area; P = perimeter area; O = outdoors.

[c] Parenthetical entries are mean airborne asbestos concentrations (s/cm^3) associated with that sampling location.

[d] Sampling locations (means) connected by a line are not statistically significantly different. For example, at Site B, the average levels in the previously abated area and perimeter area are not significantly different, but are both significantly greater than the average level outdoors.

Comparison of Previously Abated Area With Outdoors

At 6 of the 20 sites (Sites B, E, F, G, K, and Q) mean airborne asbestos concentrations in the previously abated area were significantly higher than those outdoors. Mean concentrations in the previously abated area were at least one order of magnitude (i.e., 10 times) greater than the mean concentrations outdoors. At all of the other 14 sites, the difference between mean levels in the previously abated areas and outdoors was not statistically significant.

Comparison of Perimeter Area With Outdoors

At 4 of the 20 sites (Sites B, F, N, and Q) mean airborne asbestos concentrations in the perimeter area were significantly higher (at least one order of magnitude) than those outdoors. At the remaining 16 sites, the difference between mean levels in the perimeter areas and outdoors was not statistically significant.

Comparison of Previously Abated Area With the Perimeter Area

At 3 of the 20 sites (Sites E, G, and K) mean airborne asbestos concentrations in the previously abated area were significantly greater than those in the perimeter area. Mean concentrations in the previously abated area were approximately 4 times greater than those in the perimeter area at Site E, approximately 5 times greater at Site G, and approximately 14 times greater at Site K. At all of the other 17 sites, the difference between mean concentrations in the previously abated area and the perimeter areas was not statistically significant.

Overall Structure Morphology and Length Distributions

Table 8 presents the overall distribution of structure type and morphology at each sampling location. The TEM analysis of 100 samples collected during occupied conditions in the previously abated area, 94 samples collected in the perimeter area, and 85 samples collected outdoors yielded a total of 601 asbestos structures, 99.7 percent of which were chrysotile asbestos and 0.3 percent were amphibole. Overall, the asbestos structures were primarily fibers (66 percent), and to a lesser extent,

matrices, bundles, and clusters. Appendix B contains the asbestos type and structure morphology distributions individually for Sites A through T.

TABLE 8. OVERALL DISTRIBUTION OF ASBESTOS STRUCTURES MEASURED DURING OCCUPIED CONDITIONS AT 20 SITES (percentages)

Sampling location	Type of asbestos		Structure morphology			
	Chrysotile	Amphibole	Fibers	Bundles	Clusters	Matrices
Previously abated area	99.7	0.3	67.1	4.2	3.7	25.1
Perimeter area	100	0	85.7	0	0	14.3
Outdoors	99.4	0.6	59.2	3.6	2.4	34.9

Table 9 presents the overall cumulative size distribution of asbestos structures from samples collected at the 20 sites during occupied conditions. Overall, 1.5 percent of the measured asbestos structures were greater than 5 µm in length; most of the structures (92 percent) were less than 2 µm in length.

TABLE 9. OVERALL CUMULATIVE SIZE DISTRIBUTION OF ASBESTOS STRUCTURES MEASURED DURING OCCUPIED CONDITIONS AT 20 SITES (percentages)

Sample location	Structure length, µm					
	<1	<2	<3	<4	<5	<10
Previously abated area	70.5	94.5	98.4	99.0	99.0	99.2
Perimeter area	61.5	87.6	94.1	97.0	98.2	100
Outdoors	67.3	91.8	93.9	93.9	95.9	100

Phase III Follow-up Air Monitoring - August 1991

Follow-up air monitoring was conducted by EPA-RREL/NJDOH-EHS in August 1991 at 10 of the 20 sites (B, D-H, K, M, N, and Q). Table 10 presents the results of the follow-up air monitoring at these 10 sites. These results indicate that four sites (F, G, H, and M) showed average levels exceeding 0.02 s/cm^3 (NJDOH clearance criteria) in both the previously abated area and the perimeter areas. Based on the results at these four sites, NJDOH-EHS required response action at each of the four schools. Three of the four schools employed licensed asbestos-abatement contractors and one used in-house, trained staff to conduct response actions to reduce the levels of airborne asbestos.

Subsequent to the response actions at these four schools, EPA-RREL/NJDOH-EHS conducted follow-up air monitoring to determine the residual levels of airborne asbestos. Table 11 presents the results of this follow-up monitoring. Based on these results, NJDOH-EHS determined that further action was required at Site M. Further response actions were performed at this school, and NJDOH-EHS collected additional samples. The final results showed an average concentration of 0.005 s/cm^3 in the previously abated area and 0 s/cm^3 in the perimeter area; therefore, no further action was required at this school. Table 12 presents a comparison of the air monitoring results at the sites requiring follow-up from the initial monitoring through completion of the response actions.

NJDOH Visual Inspections

Table 13 presents a summary of the visual inspections conducted by the NJDOH-EHS in August 1991. The case history for each of the sites is provided in Appendix C.

Asbestos-containing debris (including fireproofing, TSI, ceiling tile, and plaster dust) was present at all of the 10 sites. The sources of the debris were the 1988 abatement, abatements that occurred after 1988, and/or O&M activities.

TABLE 10. FOLLOWUP AIR MONITORING RESULTS AT TEN SITES (PHASE IIIa)

Site	Previously abated area			Perimeter area			Outdoors		
	Asbestos concentration, s/cm^3 (N=5)			Asbestos concentration, s/cm^3 (N=5)			Asbestos concentration, s/cm^3 (N=5)		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum
B	0.018	0	0.064	0.001	0	0.005	0.001	0	0.005
D	0.016	0	0.058	0	0	0	0.001	0	0.005
E	0.005	0	0.025	0.010	0	0.030	0.001	0	0.005
F	0.023	0.014	0.037	0.024	0	0.047	0.004	0	0.010
G	0.048	0.028	0.080	0.063	0.022	0.181	0.013	0.009	0.015
H	0.035	0.006	0.061	0.013	0	0.025	0	0	0
K	0.004	0	0.006	0.001	0	0.005	0.003	0	0.009
M	0.033	0.008	0.082	0.013	0	0.031	0.001	0	0.004
N	0.003	0	0.013	0.002	0	0.005	0.003	0	0.009
Q	0.005	0.005	0.005	0.001	0	0.005	0.001	0	0.005

Note: Sites N and Q did not have elevated levels in May 1991 but were remonitored since they were located in schools where levels were elevated.

TABLE 11. FOLLOWUP AIR MONITORING RESULTS AT FOUR SITES (PHASE IIIb)

Site	Previously abated area			Perimeter area			Outdoors		
	Asbestos concentration, s/cm^3 (N=5)			Asbestos concentration, s/cm^3 (N=5)			Asbestos concentration, s/cm^3 (N=5)		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum
F	0	0	0	0.003	0	0.008	0.001	0	0.004
G	0.010	0	0.044	0.004	0	0.010	0.005	0	0.015
H	0.016	0	0.073	0	0	0	0.001	0	0.005
M	0.001	0	0.005	0.029	0	0.131	0	0	0

TABLE 12. COMPARISON OF AIR MONITORING RESULTS AT SITES REQUIRING FOLLOW-UP

Site	Previously abated area				Perimeter area			
	Mean asbestos concentration, s/cm³				Mean asbestos concentration, s/cm³			
	III	IIIa	IIIb	IIIc	III	IIIa	IIIb	IIIc
	May 1991	Early Aug. 1991	Late Aug. 1991	Sept. 1991	May 1991	Early Aug. 1991	Late Aug. 1991	Sept. 1991
F	0.043	0.023	0		0.036	0.024	0.003	
K	0.041	0.004			0.003	0.001		
E	0.037	0.005			0.010	0.010		
H	0.004[a]	0.035	0.016		0.005	0.013	0	
B	0.027	0.018			0.012	0.001		
G	0.027	0.048	0.010		0.005	0.063	0.004	
M	0.023	0.033	0.001	0.005	0.004	0.013	0.029	0
D	0.020	0.016			0.004	0		
N	0.004	0.003			0.015	0.002		
Q	0.009	0.005			0.012	0.001		

[a] If the QA/QC replicate analyses are included, the average concentration is 0.03 s/cm³.

TABLE 13. SUMMARY OF NJDOH-EHS VISUAL INSPECTIONS CONDUCTED IN AUGUST 1991

	Sites										
	B	C	D	E	F	G	H	K	M	Q	Total
Asbestos-containing debris present	X	X	X	X	X	X	X	X	X	X	10
ACBM present, not identified in Management Plan	X			X	X		X	X		X	6
Misidentification and location of ACBM in Management Plan					X						1

Six sites (B, E, F, K, H and Q) contained at least one asbestos-containing building material not identified in the original AHERA inspection; i.e., the original AHERA inspection did not record the presence of this material in the Management Plan for the school. The previously unidentified materials included ventilation duct insulation and TSI. (These data were provided to the school officials, and the schools have reportedly corrected their Management Plans accordingly.)

At one site (Site F), the Management Plan was in error regarding the identification and location of ACM. The Management Plan indicated the presence of spray-on materials. No spray-on materials were present; however, TSI was found. (These data were provided to the school officials, and the school has reportedly corrected its Management Plan accordingly.)

Comparison of 1988, 1990, and 1991 Results

Table 14 presents the arithmetic mean concentrations of airborne asbestos measured in the previously abated area, perimeter area, and outdoors during Phase I (post-abatement, 1988), Phase II (simulated occupancy, 1990), and Phase III (occupied conditions, 1991) for all 20 sites. Individual single-factor ANOVAs were used to compare mean concentrations measured in 1988, 1990, and 1991. Each site and sampling location was evaluated separately. The results of the ANOVA analyses along with the results from the Tukey multiple comparison procedure are presented in Table 15. The remaining subsections summarize the pairwise comparisons of mean concentrations measured in 1988, 1990, and 1991. Figures D-1 through D-20 in Appendix D illustrate the average airborne asbestos concentrations in 1988, 1990, and 1991 in all three sampling locations.

Post-Abatement (1988) vs. Simulated Occupancy (1990)

Previously Abated Area

On average, concentrations measured during simulated occupancy (1990) in the previously abated area were significantly less than the post-abatement

TABLE 14. MEAN CONCENTRATIONS OF AIRBORNE ASBESTOS MEASURED AT 20 SITES IN 1988, 1990, AND MAY 1991

Site	Mean asbestos concentration, s/cm^3								
	Previously abated area			Perimeter area			Outdoors		
	1988	1990	1991	1988	1990	1991	1988	1990	1991
A	0.002	0.007	0.001	0.001	0.011	0.003	0	0	0.003
B	0.016	0.015	0.027	0.008	0.010	0.012	0.001	0.001	0.001
C	0.060	0.001	0.005	0.002	0.001	0.001	0.004	0	0.003
D	0.070	0.001	0.020	0.062	0.001	0.004	0.052	0	0.004
E	0	0.004	0.037	0	0.006	0.010	0	0	0.003
F	0.024	0.001	0.043	0.002	0.005	0.036	0.001	0	0.001
G	0.007	0.001	0.027	0.010	0.001	0.005	0	0.001	0.001
H	0.016	0	0.004	0.062	0	0.005	0.003	0	0.003
I	0	0.001	0.003	0	0.011	0.005	0.005	0.001	0.005
J	0.004	0	0.003	0.001	0.003	0	0.001	0	0.001
K	0.063	0	0.041	0.008	0.007	0.003	0	0.001	0
L	0.118	0.002	0.006	0.060	0.001	0.003	0.004	0	0
M	0.322	0	0.023	0.002	0	0.004	0.002	0	0.003
N	0.100	0.007	0.004	0.003	0.004	0.015	0.004	0.001	0
O	0.040	0.001	0.005	0.003	0.018	0	0.001	0.001	0.001
P	0.005	0.005	0.004	0.007	0	0.001	0.003	0	0
Q	0.099	0.019	0.009	0.055	0.010	0.012	0.007	0.001	0.001
R	0.002	0	0.005	0	0.011	0.001	0	0.013	0.004
S	0.012	0.003	0.001	0.003	0.001	0.003	0	0	0.001
T	0.049	0.001	0.001	0.030	0.001	0.001	0.015	0.005	0

TABLE 15. SUMMARY OF ANOVA RESULTS FOR AIRBORNE ASBESTOS CONCENTRATIONS MEASURED IN 1988, 1990, AND 1991 AT 20 SITES

Site	Location	ANOVA p-value[a]	Statistically significant differences in mean airborne asbestos concentrations[b,c]
A	Previously abated area	0.4892	1990(0.007) 1988(0.002) 1991(0.001)
	Perimeter area	0.3819	1990(0.011) 1991(0.003) 1988(0.001)
	Outdoors	0.0007	1991(0.003) 1990(0) 1988(0)
B	Previously abated area	0.4446	1991(0.027) 1988(0.016) 1990(0.015)
	Perimeter area	0.4684	1991(0.012) 1990(0.010) 1988(0.008)
	Outdoors	0.9941	1991(0) 1990(0) 1988(0)
C	Previously abated area	0.0042	1988(0.060) 1991(0.005) 1990(0.001)
	Perimeter area	0.9308	1988(0.002) 1991(0.001) 1990(0.001)
	Outdoors	0.2473	1988(0.004) 1991(0.003) 1990(0)
D	Previously abated area	0.0002	1988(0.070) 1991(0.020) 1990(0.001)
	Perimeter area	0.0001	1988(0.062) 1991(0.004) 1990(0.001)
	Outdoors	0.0003	1988(0.052) 1991(0.004) 1990(0)
E	Previously abated area	0.0001	1991(0.037) 1990(0.004) 1988(0)
	Perimeter area	0.0690	1991(0.010) 1990(0.006) 1988(0)
	Outdoors	0.0213	1991(0.003) 1990(0) 1988(0)

(continued)

TABLE 15 (continued)

Site	Location	ANOVA p-value[a]	Statistically significant differences in mean airborne asbestos concentrations[b,c]
F	Previously abated area	0.0001	1991(0.043) 1988(0.024) 1990(0.001)
	Perimeter area	0.0013	1991(0.036) 1990(0.005) 1988(0.002)
	Outdoors	0.6080	1991(0.001) 1988(0.001) 1990(0)
G	Previously abated area	0.0010	1991(0.027) 1988(0.007) 1990(0.001)
	Perimeter area	0.2247	1988(0.010) 1991(0.005) 1990(0.001)
	Outdoors	0.3974	1991(0.001) 1990(0.001) 1988(0)
H	Previously abated area	0.0024	1988(0.016) 1991(0.004) 1990(0)
	Perimeter area	0.0004	1988(0.062) 1991(0.005) 1990(0)
	Outdoors	0.1151	1988(0.003) 1991(0.003) 1990(0)
I	Previously abated area	0.1102	1991(0.003) 1990(0.001) 1988(0)
	Perimeter area	0.2217	1990(0.011) 1991(0.005) 1988(0)
	Outdoors	0.5078	1991(0.005) 1988(0.005) 1990(0.001)
J	Previously abated area	0.0144	1988(0.004) 1991(0.003) 1990(0)
	Perimeter area	0.0797	1990(0.003) 1988(0.001) 1991(0)
	Outdoors	0.6186	1991(0.001) 1988(0.001) 1990(0)
K	Previously abated area	0.001	1988(0.063) 1991(0.041) 1990(0)
	Perimeter area	0.5854	1988(0.008) 1990(0.007) 1991(0.003)
	Outdoors	0.3966	1990(0.001) 1991(0) 1988(0)

(continued)

TABLE 15 (continued)

Site	Location	ANOVA p-value[a]	Statistically significant differences in mean airborne asbestos concentrations[b,c]
L	Previously abated area	0.0001	1988(0.118) 1991(0.006) 1990(0.002)
	Perimeter area	0.0001	1988(0.060) 1991(0.003) 1990(0.001)
	Outdoors	0.1453	1988(0.004) 1990(0) 1991(0)
M	Previously abated area	0.0001	1988(0.322) 1991(0.023) 1990(0)
	Perimeter area	0.0597	1991(0.004) 1988(0.002) 1990(0)
	Outdoors	0.1078	1991(0.003) 1988(0.002) 1990(0)
N	Previously abated area	0.0001	1988(0.100) 1990(0.007) 1991(0.004)
	Perimeter area	0.2257	1991(0.015) 1990(0.004) 1988(0.003)
	Outdoors	0.0004	1988(0.004) 1990(0.001) 1991(0)
O	Previously abated area	0.2858	1988(0.040) 1991(0.005) 1990(0.001)
	Perimeter area	0.3603	1990(0.018) 1988(0.003) 1991(0)
	Outdoors	0.8955	1988(0.001) 1990(0.001) 1991(0.001)
P	Previously abated area	0.8002	1988(0.005) 1990(0.005) 1991(0.004)
	Perimeter area	0.0118	1988(0.007) 1991(0.001) 1990(0)
	Outdoors	0.3966	1988(0.003) 1990(0) 1991(0)
Q	Previously abated area	0.0047	1988(0.099) 1990(0.019) 1991(0.009)
	Perimeter area	0.1365	1988(0.055) 1991(0.012) 1990(0.010)
	Outdoors	0.1927	1988(0.007) 1990(0.001) 1991(0.001)

(continued)

TABLE 15 (continued)

Site	Location	ANOVA p-value[a]	Statistically significant differences in mean airborne asbestos concentrations[b,c]
R	Previously abated area	0.0423	1991(0.005) 1988(0.002) 1990(0)
	Perimeter area	0.0086	1990(0.011) 1991(0.001) 1988(0)
	Outdoors	0.0336	1990(0.013) 1991(0.004) 1988(0)
S	Previously abated area	0.1587	1988(0.012) 1990(0.003) 1991(0.001)
	Perimeter area	0.5419	1988(0.003) 1991(0.003) 1990(0.001)
	Outdoors	0.3966	1991(0.001) 1988(0) 1990(0)
T	Previously abated area	0.0001	1988(0.049) 1990(0.001) 1991(0.001)
	Perimeter area	0.0129	1988(0.030) 1990(0.001) 1991(0.001)
	Outdoors	0.2324	1988(0.015) 1990(0.005) 1991(0)

[a] If the ANOVA p-value was less than 0.05, then the Tukey multiple comparison procedure was used to distinguish pairwise differences between mean concentrations measured in 1988, 1990, 1991.

[b] Parenthetical entries are mean airborne asbestos concentrations (s/cm^3) associated with that year's monitoring.

[c] Years (means) connected by a line are not statistically significantly different. For example, the average level measured in the previously abated area at Site C was significantly greater in 1988 than in 1990 and 1991; the difference between the average levels measured in 1990 and 1991 was not statistically significant.

concentrations (1988) at 11 of the 20 sites (Sites C, D, F, H, J-N, Q, and T). At the remaining nine sites, no significant differences were noted.

Perimeter Area

On average, concentrations measured during simulated occupancy (1990) in the perimeter area were significantly less than the post-abatement concentrations (1988), at 5 of the 20 sites (Sites D, H, L, P, and T). At only one of the sites was the mean concentration significantly greater during simulated occupancy than during post abatement (Site R). At the remaining 14 sites, no significant differences were noted.

Outdoors

On average, concentrations measured outdoors in 1990 were significantly less than concentrations measured in 1988 at 2 of the 20 sites (Sites D and N). At only one site was the mean outdoor concentration greater in 1990 than in 1988 (Site R). At the remaining 17 sites, no significant differences were noted.

Post-Abatement (1988) vs. Occupied Conditions (1991)

Previously Abated Area

On average, concentrations measured in the previously abated area during occupied conditions (1991) were significantly less than the post-abatement concentrations (1988) at 8 of the 20 sites (Sites C, D, H, L-N, Q, and T). At two sites (Sites E and G), mean concentrations of airborne asbestos were significantly higher in the previously abated area during occupied conditions in 1991 than post-abatement in 1988. At the remaining 10 sites, no significant differences were noted.

Perimeter Area

On average, concentrations measured in the perimeter area during occupied conditions (1991) were significantly less than the post-abatement concentrations (1988) at 5 of the 20 sites (Sites D, H, L, P, and T). At only one of the sites (Site F) was the mean concentration significantly greater during occupied conditions than post abatement. At the remaining 14 sites, no significant differences were noted.

Outdoors

On average, concentrations measured outdoors in 1991 were significantly less than concentrations measured in 1988 at 2 of the 20 sites (Sites D and N). The mean outdoor concentration was greater in 1991 than in 1988 at two sites (Sites A and E). At the remaining 16 sites, no significant differences were noted.

Simulated Occupancy (1990) vs. Occupied Conditions (1991)

Previously Abated Area

On average, concentrations measured in the previously abated area during occupied conditions (1991) were significantly greater than those measured during simulated occupancy (1990) at 7 of the 20 sites (Sites D-G, K, M, and R). At the remaining 13 sites, no significant differences were noted.

Perimeter Area

On average, concentrations measured during occupied conditions (1991) were significantly greater than those measured in the perimeter area during simulated occupancy (1990) at only 1 of the 20 sites (Site F). Conversely, on average, Site R showed significantly greater concentrations during simulated occupancy than during actual occupied conditions. At the remaining 12 sites, no significant differences were noted.

Outdoors

Mean outdoor concentrations of airborne asbestos measured in 1991 were significantly greater than concentrations measured in 1990 at 2 of the 20 sites (Sites A and E). At the remaining 16 sites, no significant differences were noted.

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APPENDIX A

INDIVIDUAL ESTIMATES OF AIRBORNE ASBESTOS CONCENTRATIONS THREE YEARS AFTER ABATEMENT (1991) AT 20 SITES

APPENDIX A
INDIVIDUAL ESTIMATES OF AIRBORNE ASBESTOS CONCENTRATIONS THREE YEARS AFTER ABATEMENT (1991) AT 20 SITES

Site	Sample date	Sample number	Sampling locataion	Concentration s/cm³	Concentration s/mm²	Air Volume, L
A	05/01/91	A91-11-A	Previously abated area	0	0	2340
A	05/01/91	A91-12-A	Previously abated area	0	0	2311
A	05/01/91	A91-13-A	Previously abated area	0	0	2279
A	05/01/91	A91-14-A	Previously abated area	0.003	16	2282
A	05/01/91	A91-15-A	Previously abated area	0	0	1851
A	05/01/91	A91-01-O	Outdoors	0.003	16	2256
A	05/01/91	A91-02-O	Outdoors	0.005	31	2250
A	05/01/91	A91-03-O	Outdoors	0	0	2239
A	05/01/91	A91-04-O	Outdoors	0.005	31	2239
A	05/01/91	A91-05-O	Outdoors	0.003	16	2258
A	05/01/91	A91-06-P	Perimeter area	0.003	16	2346
A	05/01/91	A91-07-P	Perimeter area	0	0	2322
A	05/01/91	A91-08-P	Perimeter area	0.005	31	2256
A	05/01/91	A91-09-P	Perimeter area	0	0	2239
A	05/01/91	A91-09-PR	Replicate of A91-09-P	0.003	18	2239
A	05/01/91	A91-10-P	Perimeter area	0.008	47	2227
B	05/09/91	B91-11-A	Previously abated area	0.014	71	2016
B	05/09/91	B91-12-A	Previously abated area	0.044	232	2016
B	05/09/91	B91-13-A	Previously abated area	0.014	71	2010
B	05/09/91	B91-14-A	Previously abated area	0.055	286	2010
B	05/09/91	B91-15-A	Previously abated area	0.010	54	1986
B	05/09/91	BQ91-01-O	Outdoors	0	0	1908
B	05/09/91	BQ91-02-O	Outdoors	0	0	1932
B	05/09/91	BQ91-03-O	Outdoors	0	0	1970
B	05/09/91	BQ91-04-O	Outdoors	0.004	18	1944
B	05/09/91	BQ91-05-O	Outdoors	0	0	1944
B	05/09/91	BQ91-06-P	Perimeter area	0.014	71	1914
B	05/09/91	BQ91-07-P	Perimeter area	0.011	54	1884
B	05/09/91	BQ91-08-P	Perimeter area	0.004	18	1946
B	05/09/91	BQ91-09-P	Perimeter area	0.007	36	1980
B	05/09/91	BQ91-10-P	Perimeter area	0.024	125	2025
B	08/13/91	B-891-11A	Previously abated area	0.013	54	1558
B	08/13/91	B-891-12A	Previously abated area	0.009	36	1513
B	08/13/91	B-891-13A	Previously abated area	0.064	232	1391
B	08/13/91	B-891-14A	Previously abated area	0	0	1488
B	08/13/91	B-891-15A	Previously abated area	0.004	18	1566
B	08/13/91	BQ-891-01	Outdoors	0.005	18	1352
B	08/13/91	BQ-891-02	Outdoors	0	0	1263
B	08/13/91	BQ-891-03	Outdoors	0	0	1456
B	08/13/91	BQ-891-04	Outdoors	0	0	1547
B	08/13/91	BQ-891-05	Outdoors	0	0	1575
B	08/13/91	BQ-891-06	Perimeter area	0	0	1391
B	08/13/91	BQ-891-07	Perimeter area	0.005	18	1488
B	08/13/91	BQ-891-08	Perimeter area	0	0	1445
B	08/13/91	BQ-891-09	Perimeter area	0	0	1410
B	08/13/91	BQ-891-10	Perimeter area	0	0	1436
C	05/01/91	C91-11-A	Previously abated area	0.012	63	1961
C	05/01/91	C91-12-A	Previously abated area	0	0	1984
C	05/01/91	C91-13-A	Previously abated area	0.003	16	1961
C	05/01/91	C91-14-A	Previously abated area	0	0	1972
C	05/01/91	C91-15-A	Previously abated area	0.009	47	1915
C	05/01/91	C91-01-O	Outdoors	0	0	2536
C	05/01/91	C91-02-O	Outdoors	0	0	2528

(continued)

APPENDIX A (continued)

Site	Sample date	Sample number	Sampling locataion	Concentration s/cm³	Concentration s/mm²	Air Volume, L
C	05/01/91	C91-03-O	Outdoors	0.007	47	2528
C	05/01/91	C91-04-O	Outdoors	0.005	31	2512
C	05/01/91	C91-05-O	Outdoors	0.002	16	2504
C	05/01/91	C91-06-P	Perimeter area	0	0	1995
C	05/01/91	C91-07-P	Perimeter area	0.003	16	2006
C	05/01/91	C91-08-P	Perimeter area	0	0	1898
C	05/01/91	C91-09-P	Perimeter area	0	0	1990
C	05/01/91	C91-10-P	Perimeter area	0	0	1790
D	04/30/91	D91-11-A	Previously abated area	0.012	63	2063
D	04/30/91	D91-12-A	Previously abated area	0.059	297	1948
D	04/30/91	D91-13-A	Previously abated area	0.006	31	2028
D	04/30/91	D91-13-AR	Replicate of D-91-13-A	0.014	71	2028
D	04/30/91	D91-14-A	Previously abated area	0.020	109	2058
D	04/30/91	D91-15-A	Previously abated area	0.003	16	2023
D	04/30/91	D91-01-O	Outdoors	0.003	16	1995
D	04/30/91	D91-02-O	Outdoors	0.012	63	1995
D	04/30/91	D91-03-O	Outdoors	0.002	13	1966
D	04/30/91	D91-04-O	Outdoors	0.003	16	1955
D	04/30/91	D91-05-O	Outdoors	0	0	1972
D	04/30/91	D91-06-P	Perimeter area	0.008	42	2052
D	04/30/91	D91-07-P	Perimeter area	0.003	14	2052
D	04/30/91	D91-08-P	Perimeter area	0	0	2058
D	04/30/91	D91-09-P	Perimeter area	0.009	47	2081
D	04/30/91	D91-10-P	Perimeter area	0.003	16	2052
D	08/13/91	D-891-11A	Previously abated area	0	0	1506
D	08/13/91	D-891-12A	Previously abated area	0.058	214	1434
D	08/13/91	D-891-13A	Previously abated area	0.010	36	1417
D	08/13/91	D-891-14A	Previously abated area	0.014	54	1479
D	08/13/91	D-891-15A	Previously abated area	0	0	1496
D	08/13/91	D-891-01O	Outdoors	0.005	18	1469
D	08/13/91	D-891-02O	Outdoors	0	0	1434
D	08/13/91	D-891-03O	Outdoors	0	0	1442
D	08/13/91	D-891-04O	Outdoors	0	0	1477
D	08/13/91	D-891-05O	Outdoors	0	0	1451
D	08/13/91	D-891-06P	Perimeter area	0	0	1469
D	08/13/91	D-891-07P	Perimeter area	0	0	1443
D	08/13/91	D-891-08P	Perimeter area	0	0	1451
D	08/13/91	D-891-09P	Perimeter area	0	0	1524
D	08/13/91	D-891-10P	Perimeter area	0	0	1534
E	05/06/91	E91-11-A	Previously abated area	0.011	54	1921
E	05/06/91	E91-12-A	Previously abated area	0.069	357	1989
E	05/06/91	E91-13-A	Previously abated area	0.042	232	2142
E	05/06/91	E91-14-A	Previously abated area	0.029	161	2135
E	05/06/91	E91-15-A	Previously abated area	0.032	161	1921
E	05/06/91	E91-01-O	Outdoors	0.007	36	2094
E	05/06/91	E91-02-O	Outdoors	0.007	36	2100
E	05/06/91	E91-03-O	Outdoors	0	0	1931
E	05/06/91	E91-04-O	Outdoors	0.003	18	2094
E	05/06/91	E91-05-O	Outdoors	0	0	2094
E	05/06/91	E91-06-P	Perimeter area	0.003	16	1910
E	05/06/91	E91-07-P	Perimeter area	0.003	16	1943
E	05/06/91	E91-08-P	Perimeter area	0.029	143	1910
E	05/06/91	E91-09-P	Perimeter area	0.015	71	1887
E	05/06/91	E91-10-P	Perimeter area	0	0	1853
E	08/12/91	E-891-11A	Previously abated area	0.025	89	1377
E	08/12/91	E-891-12A	Previously abated area	0	0	1371
E	08/12/91	E-891-13A	Previously abated area	0	0	1328

(continued)

APPENDIX A (continued)

Site	Sample date	Sample number	Sampling locataion	Concentration s/cm³	Concentration s/mm²	Air Volume, L
E	08/12/91	E-891-14A	Previously abated area	0	0	1328
E	08/12/91	E-891-15A	Previously abated area	0	0	1328
E	08/12/91	E-891-01O	Outdoors	0.005	18	1433
E	08/12/91	E-891-02O	Outdoors	0	0	1440
E	08/12/91	E-891-03O	Outdoors	0	0	1415
E	08/12/91	E-891-04O	Outdoors	0	0	1438
E	08/12/91	E-891-05O	Outdoors	0	0	1420
E	08/12/91	E-891-06P	Perimeter area	0.010	36	1388
E	08/12/91	E-891-07P	Perimeter area	0	0	1395
E	08/12/91	E-891-08P	Perimeter area	0.030	107	1386
E	08/12/91	E-891-09P	Perimeter area	0.010	36	1401
E	08/12/91	E-891-10P	Perimeter area	0	0	1484
F	05/09/91	F91-11-A	Previously abated area	0.035	179	1976
F	05/09/91	F91-11-AR	Replicate of F91-11-A	0.028	143	1976
F	05/09/91	F91-12-A	Previously abated area	0.066	339	1976
F	05/09/91	F91-12-AD	Duplicate of F91-12-A	0.038	196	1976
F	05/09/91	F91-13-A	Previously abated area	0.039	196	1944
F	05/09/91	F91-14-A	Previously abated area	0.042	214	1980
F	05/09/91	F91-15-A	Previously abated area	0.032	161	1932
F	05/09/91	F91-01-O	Outdoors	0	0	1995
F	05/09/91	F91-02-O	Outdoors	0	0	1995
F	05/09/91	F91-03-O	Outdoors	0.002	13	1983
F	05/09/91	F91-04-O	Outdoors	0	0	1989
F	05/09/91	F91-05-O	Outdoors	0	0	1976
F	05/09/91	F91-06-P	Perimeter area	0.010	54	2037
F	05/09/91	F91-07-P	Perimeter area	0.058	304	2019
F	05/09/91	F91-08-P	Perimeter area	0.035	179	1989
F	05/09/91	F91-09-P	Perimeter area	0.025	125	1944
F	05/09/91	F91-09-PD	Duplicate of F91-09-P	0.007	36	1944
F	05/09/91	F91-10-P	Perimeter area	0.054	268	1907
F	05/09/91	F91-10-PD	Duplicate of F91-10-P	0.047	232	1907
F	08/12/91	F-891-11A	Previously abated area	0.037	143	1477
F	08/12/91	F-891-12A	Previously abated area	0.014	54	1440
F	08/12/91	F-891-13A	Previously abated area	0.029	107	1424
F	08/12/91	F-891-14A	Previously abated area	0.015	54	1381
F	08/12/91	F-891-15A	Previously abated area	0.019	71	1414
F	08/12/91	F-891-01O	Outdoors	0	0	1345
F	08/12/91	F-891-02O	Outdoors	0.005	18	1387
F	08/12/91	F-891-03O	Outdoors	0.010	36	1362
F	08/12/91	F-891-04O	Outdoors	0.005	18	1345
F	08/12/91	F-891-05O	Outdoors	0	0	1337
F	08/12/91	F-891-06P	Perimeter area	0.046	161	1354
F	08/12/91	F-891-07P	Perimeter area	0.047	161	1319
F	08/12/91	F-891-08P	Perimeter area	0.010	36	1354
F	08/12/91	F-891-09P	Perimeter area	0	0	1380
F	08/12/91	F-891-10P	Perimeter area	0.019	71	1431
F	08/28/91	F-8B91-11	Previously abated area	0	0	1695
F	08/28/91	F-8B91-12	Previously abated area	0	0	1588
F	08/28/91	F-8B91-13	Previously abated area	0	0	1598
F	08/28/91	F-8B91-14	Previously abated area	0	0	1543
F	08/28/91	F-8B91-15	Previously abated area	0	0	1499
F	08/28/91	F-8B91-01	Outdoors	0	0	1471
F	08/28/91	F-8B91-02	Outdoors	0.004	18	1648
F	08/28/91	F-8B91-03	Outdoors	0	0	1551
F	08/28/91	F-8B91-04	Outdoors	0	0	1410
F	08/28/91	F-8B91-05	Outdoors	0	0	1419
F	08/28/91	F-8B91-06	Perimeter area	0.005	18	1527

(continued)

APPENDIX A (continued)

Site	Sample date	Sample number	Sampling locataion	Concentration s/cm³	Concentration s/mm²	Air Volume, L
F	08/28/91	F-8B91-07	Perimeter area	0.004	18	1687
F	08/28/91	F-8B91-08	Perimeter area	0.008	36	1657
F	08/28/91	F-8B91-09	Perimeter area	0	0	1648
F	08/28/91	F-8B91-10	Perimeter area	0	0	1671
G	05/03/91	G91-11-A	Previously abated area	0.032	161	1921
G	05/03/91	G91-12-A	Previously abated area	0.025	125	1921
G	05/03/91	G91-13-A	Previously abated area	0.011	54	1910
G	05/03/91	G91-14-A	Previously abated area	0.030	143	1859
G	05/03/91	G91-15-A	Previously abated area	0.037	179	1881
G	05/03/91	G91-01-O	Outdoors	0.003	18	1994
G	05/03/91	G91-02-O	Outdoors	0	0	1944
G	05/03/91	G91-03-O	Outdoors	0.004	18	1921
G	05/03/91	G91-04-O	Outdoors	0	0	1882
G	05/03/91	G91-05-O	Outdoors	0	0	1910
G	05/03/91	G91-06-P	Perimeter area	0	0	1904
G	05/03/91	G91-07-P	Perimeter area	0	0	1938
G	05/03/91	G91-08-P	Perimeter area	0.011	54	1927
G	05/03/91	G91-09-P	Perimeter area	0.007	36	1926
G	05/03/91	G91-10-P	Perimeter area	0.007	36	1835
G	08/14/91	G-891-11A	Previously abated area	0.028	107	1452
G	08/14/91	G-891-12A	Previously abated area	0.080	286	1381
G	08/14/91	G-891-13A	Previously abated area	0.068	250	1417
G	08/14/91	G-891-14A	Previously abated area	0.035	125	1390
G	08/14/91	G-891-15A	Previously abated area	0.029	107	1443
G	08/14/91	G-891-01O	Outdoors	0.015	54	1389
G	08/14/91	G-891-02O	Outdoors	0.015	54	1416
G	08/14/91	G-891-03O	Outdoors	0.013	54	1544
G	08/14/91	G-891-04O	Outdoors	0.009	36	1480
G	08/14/91	G-891-05O	Outdoors	0.015	54	1416
G	08/14/91	G-891-06P	Perimeter area	0.022	89	1543
G	08/14/91	G-891-07P	Perimeter area	0.181	643	1371
G	08/14/91	G-891-08P	Perimeter area	0.029	107	1444
G	08/14/91	G-891-09P	Perimeter area	0.034	125	1426
G	08/14/91	G-891-10P	Perimeter area	0.051	196	1479
G	08/26/91	G-8B91-11	Previously abated area	0	0	1587
G	08/26/91	G-8B91-12	Previously abated area	0.005	18	1385
G	08/26/91	G-8B91-13	Previously abated area	0.044	161	1394
G	08/26/91	G-8B91-14	Previously abated area	0	0	1424
G	08/26/91	G-8B91-15	Previously abated area	0	0	1404
G	08/26/91	G-8B91-01	Outdoors	0.005	18	1440
G	08/26/91	G-8B91-02	Outdoors	0	0	1287
G	08/26/91	G-8B91-03	Outdoors	0	0	1500
G	08/26/91	G-8B91-04	Outdoors	0.004	18	1547
G	08/26/91	G-8B91-05	Outdoors	0.015	54	1421
G	08/26/91	G-8B91-06	Perimeter area	0.009	36	1500
G	08/26/91	G-8B91-07	Perimeter area	0.010	36	1415
G	08/26/91	G-8B91-08	Perimeter area	0	0	1347
G	08/26/91	G-8B91-09	Perimeter area	0	0	1434
G	08/26/91	G-8B91-10	Perimeter area	0	0	1443
H	04/30/91	H91-11-A	Previously abated area	0.014	78	2220
H	04/30/91	H91-11-AR	Replicate of H91-11-A	0.003	18	2220
H	04/30/91	H91-12-A	Previously abated area	0.003	16	2258
H	04/30/91	H91-12-AR	Replicate of H91-12-A	0.015	89	2258
H	04/30/91	H91-13-A	Previously abated area	0	0	2233
H	04/30/91	H91-13-AR	Replicate of H91-13-A	0.102	589	2233
H	04/30/91	H91-13-AR	Replicate of H91-13-A	0.009	54	2233
H	04/30/91	H91-14-A	Previously abated area	0.003	16	2264

(continued)

APPENDIX A (continued)

Site	Sample date	Sample number	Sampling locataion	Concentration s/cm³	Concentration s/mm²	Air Volume, L
H	04/30/91	H91-14-AR	Replicate of H91-14-A	0.003	18	2264
H	04/30/91	H91-15-A	Previously abated area	0	0	2187
H	04/30/91	H91-15-AR	Replicate of H91-15-A	0.025	143	2187
H	04/30/91	H91-01-O	Outdoors	0	0	2200
H	04/30/91	H91-02-O	Outdoors	0.003	16	2216
H	04/30/91	H91-02-OD	Outdoors	0	0	2216
H	04/30/91	H91-03-O	Outdoors	0.003	16	2221
H	04/30/91	H91-04-O	Outdoors	0.005	31	2203
H	04/30/91	H91-05-O	Outdoors	0.003	16	2221
H	04/30/91	H91-06-P	Perimeter area	0.011	63	2282
H	04/30/91	H91-07-P	Perimeter area	0.008	47	2256
H	04/30/91	H91-08-P	Perimeter area	0	0	2287
H	04/30/91	H91-09-P	Perimeter area	0	0	2256
H	04/30/91	H91-10-P	Perimeter area	0.008	47	2258
H	08/15/91	H-891-11A	Previously abated area	0.061	196	1240
H	08/15/91	H-891-12A	Previously abated area	0.005	18	1251
H	08/15/91	H-891-13A	Previously abated area	0.048	179	1428
H	08/15/91	H-891-14A	Previously abated area	0.050	179	1385
H	08/15/91	H-891-15A	Previously abated area	0.011	36	1263
H	08/15/91	H-891-01O	Outdoors	0	0	1348
H	08/15/91	H-891-02O	Outdoors	0	0	1453
H	08/15/91	H-891-03O	Outdoors	0	0	1549
H	08/15/91	H-891-04O	Outdoors	0	0	1365
H	08/15/91	H-891-05O	Outdoors	0	0	1401
H	08/15/91	H-891-06P	Perimeter area	0.005	18	1470
H	08/15/91	H-891-07P	Perimeter area	0.020	71	1410
H	08/15/91	H-891-08P	Perimeter area	0	0	1335
H	08/15/91	H-891-09P	Perimeter area	0.014	54	1505
H	08/15/91	H-891-10P	Perimeter area	0.025	89	1360
H	08/29/91	H-8B91-11	Previously abated area	0.073	268	1414
H	08/29/91	H-8B91-12	Previously abated area	0	0	1306
H	08/29/91	H-8B91-13	Previously abated area	0	0	1289
H	08/29/91	H-8B91-14	Previously abated area	0	0	1414
H	08/29/91	H-8B91-15	Previously abated area	0.005	18	1324
H	08/29/91	H-8B91-01	Outdoors	0	0	1401
H	08/29/91	H-8B91-02	Outdoors	0.005	18	1308
H	08/29/91	H-8B91-03	Outdoors	0	0	1336
H	08/29/91	H-8B91-04	Outdoors	0	0	1403
H	08/29/91	H-8B91-05	Outdoors	0	0	1245
H	08/29/91	H-8B91-06	Perimeter area	0	0	1314
H	08/29/91	H-8B91-07	Perimeter area	0	0	1350
H	08/29/91	H-8B91-08	Perimeter area	0	0	1306
H	08/29/91	H-8B91-09	Perimeter area	0	0	1314
H	08/29/91	H-8B91-10	Perimeter area	0	0	1350
I	05/06/91	I91-11-A	Previously abated area	0	0	1881
I	05/06/91	I91-12-A	Previously abated area	0.004	18	1898
I	05/06/91	I91-13-A	Previously abated area	0.004	18	1881
I	05/06/91	I91-14-A	Previously abated area	0	0	1921
I	05/06/91	I91-15-A	Previously abated area	0.007	36	1870
I	05/06/91	I91-01-O	Outdoors	0	0	1712
I	05/06/91	I91-01-OR	Replicate of I91-01-O	0	0	1712
I	05/06/91	I91-02-O	Outdoors	0	0	1712
I	05/06/91	I91-03-O	Outdoors	0	0	1697
I	05/06/91	I91-04-O	Outdoors	0.020	89	1727
I	05/06/91	I91-05-O	Outdoors	0.004	18	1727
I	05/06/91	I91-06-P	Perimeter area	0.004	18	1927
I	05/06/91	I91-07-P	Perimeter area	0.007	36	1921

(continued)

APPENDIX A (continued)

Site	Sample date	Sample number	Sampling locataion	Concentration s/cm³	Concentration s/mm²	Air Volume, L
I	05/06/91	I91-08-P	Perimeter area	0.011	54	1898
I	05/06/91	I91-09-P	Perimeter area	0.004	18	1932
I	05/06/91	I91-10-P	Perimeter area	0	0	1466
J	05/07/91	J91-11-A	Previously abated area	0	0	1878
J	05/07/91	J91-12-A	Previously abated area	0.004	18	1841
J	05/07/91	J91-13-A	Previously abated area	0.011	54	1827
J	05/07/91	J91-14-A	Previously abated area	0	0	1859
J	05/07/91	J91-15-A	Previously abated area	0	0	1922
J	05/07/91	J91-15-AD	Duplicate of J91-15-A	0	0	1922
J	05/07/91	J91-01-O	Outdoors	0	0	1853
J	05/07/91	J91-02-O	Outdoors	0.004	18	1853
J	05/07/91	J91-03-O	Outdoors	0	0	1853
J	05/07/91	J91-04-O	Outdoors	0	0	1827
J	05/07/91	J91-05-O	Outdoors	0	0	1815
J	05/07/91	J91-06-P	Perimeter area	0	0	1878
J	05/07/91	J91-07-P	Perimeter area	0	0	1823
J	05/07/91	J91-08-P	Perimeter area	0	0	1804
J	05/07/91	J91-09-P	Perimeter area	0	0	1589
J	05/07/91	J91-10-P	Perimeter area	0	0	1847
K	04/29/91	K91-11-A	Previously abated area	0.097	238	943
K	04/29/91	K91-12-A	Previously abated area	0.014	42	1123
K	04/29/91	K91-13-A	Previously abated area	0.022	69	1214
K	04/29/91	K91-14-A	Previously abated area	0.040	125	1209
K	04/29/91	K91-15-A	Previously abated area	0.033	100	1171
K	04/29/91	KN91-01-O	Outdoors	0	0	1832
K	04/29/91	KN91-02-O	Outdoors	0	0	1832
K	04/29/91	KN91-03-O	Outdoors	0	0	1881
K	04/29/91	KN91-04-O	Outdoors	0	0	1854
K	04/29/91	KN91-05-O	Outdoors	0	0	1832
K	04/29/91	K91-06-P	Perimeter area	0	0	1931
K	04/29/91	K91-07-P	Perimeter area	0	0	1921
K	04/29/91	K91-08-P	Perimeter area	0.006	31	1938
K	04/29/91	K91-09-P	Perimeter area	0.003	16	1836
K	04/29/91	K91-10-P	Perimeter area	0.007	31	1842
K	08/14/91	K-891-11A	Previously abated area	0.006	18	1204
K	08/14/91	K-891-12A	Previously abated area	0.005	18	1408
K	08/14/91	K-891-13A	Previously abated area	0.005	18	1383
K	08/14/91	K-891-14A	Previously abated area	0	0	1264
K	08/14/91	K-891-15A	Previously abated area	0.005	18	1326
K	08/14/91	KN-891-01	Outdoors	0	0	1513
K	08/14/91	KN-891-02	Outdoors	0	0	1486
K	08/14/91	KN-891-03	Outdoors	0.009	36	1504
K	08/14/91	KN-891-04	Outdoors	0.006	18	1159
K	08/14/91	KN-891-05	Outdoors	0	0	1373
K	08/14/91	K-891-06P	Perimeter area	0	0	1304
K	08/14/91	K-891-07P	Perimeter area	0.005	18	1312
K	08/14/91	K-891-08P	Perimeter area	0	0	1342
K	08/14/91	K-891-09P	Perimeter area	0	0	1336
K	08/14/91	K-891-10P	Perimeter area	0	0	1416
L	05/07/91	L91-11-A	Previously abated area	0	0	2159
L	05/07/91	L91-12-A	Previously abated area	0.016	89	2099
L	05/07/91	L91-13-A	Previously abated area	0	0	2100
L	05/07/91	L91-14-A	Previously abated area	0.013	71	2100
L	05/07/91	L91-15-A	Previously abated area	0.003	18	2065
L	05/07/91	L91-01-O	Outdoors	0	0	2094
L	05/07/91	L91-02-O	Outdoors	0	0	2088
L	05/07/91	L91-03-O	Outdoors	0	0	2082

(continued)

APPENDIX A (continued)

Site	Sample date	Sample number	Sampling locataion	Concentration s/cm³	Concentration s/mm²	Air Volume, L
L	05/07/91	L91-04-O	Outdoors	0	0	2059
L	05/07/91	L91-05-O	Outdoors	0	0	2071
L	05/07/91	L91-06-P	Perimeter area	0.003	18	2129
L	05/07/91	L91-07-P	Perimeter area	0.006	36	2117
L	05/07/91	L91-07-PR	Replicate of L91-07-P	0	0	2117
L	05/07/91	L91-08-P	Perimeter area	0	0	2099
L	05/07/91	L91-09-P	Perimeter area	0.003	18	2111
L	05/07/91	L91-10-P	Perimeter area	0.003	18	2087
M	05/01/91	M91-11-A	Previously abated area	0.056	281	1921
M	05/01/91	M91-12-A	Previously abated area	0.038	188	1892
M	05/01/91	M91-13-A	Previously abated area	0.019	94	1892
M	05/01/91	M91-14-A	Previously abated area	0.003	16	1770
M	05/01/91	M91-15-A	Previously abated area	0	0	1835
M	05/01/91	M91-06-P	Perimeter area	0.007	36	2041
M	05/01/91	M91-08-P	Perimeter area	0.004	18	1938
M	05/01/91	M91-09-P	Perimeter area	0.007	36	2012
M	05/01/91	M91-10-P	Perimeter area	0	0	1807
M	08/13/91	M-891-11A	Previously abated area	0.008	36	1726
M	08/13/91	M-891-12A	Previously abated area	0.082	339	1590
M	08/13/91	M-891-13A	Previously abated area	0.018	71	1534
M	08/13/91	M-891-14A	Previously abated area	0.009	36	1554
M	08/13/91	M-891-15A	Previously abated area	0.046	179	1489
M	08/13/91	M-891-01O	Outdoors	0	0	1511
M	08/13/91	M-891-02O	Outdoors	0	0	1609
M	08/13/91	M-891-03O	Outdoors	0	0	1609
M	08/13/91	M-891-04O	Outdoors	0	0	1570
M	08/13/91	M-891-05O	Outdoors	0.004	18	1560
M	08/13/91	M-891-06P	Perimeter area	0	0	1540
M	08/13/91	M-891-07P	Perimeter area	0	0	1723
M	08/13/91	M-891-08P	Perimeter area	0.025	107	1673
M	08/13/91	M-891-09P	Perimeter area	0.008	36	1725
M	08/13/91	M-891-10P	Perimeter area	0.031	125	1543
M	08/29/91	M-8B91-11	Previously abated area	0	0	1429
M	08/29/91	M-8B91-12	Previously abated area	0	0	1450
M	08/29/91	M-8B91-13	Previously abated area	0	0	1383
M	08/29/91	M-8B91-14	Previously abated area	0.005	18	1386
M	08/29/91	M-8B91-15	Previously abated area	0	0	1328
M	08/29/91	M-8B91-01	Outdoors	0	0	1319
M	08/29/91	M-8B91-02	Outdoors	0	0	1263
M	08/29/91	M-8B91-03	Outdoors	0	0	1317
M	08/29/91	M-8B91-04	Outdoors	0	0	1273
M	08/29/91	M-8B91-05	Outdoors	0	0	1430
M	08/29/91	M-8B91-06	Perimeter area	0	0	1336
M	08/29/91	M-8B91-07	Perimeter area	0.005	18	1281
M	08/29/91	M-8B91-08	Perimeter area	0.005	18	1310
M	08/29/91	M-8B91-09	Perimeter area	0.005	18	1439
M	08/29/91	M-8B91-10	Perimeter area	0.131	446	1309
M	09/03/91	M-991-14A	Previously abated area	0.005	18	1477
M	09/03/91	M-991-15A	Previously abated area	0.005	18	1508
M	09/03/91	M-991-10P	Perimeter area	0	0	1337
M	09/03/91	M-991-19P	Perimeter area	0	0	1337
M	09/03/91	M-991-20P	Perimeter area	0	0	1403
M	09/03/91	M991-21P	Perimeter area	0	0	1500
M	09/03/91	M991-22P	Perimeter area	0	0	1393
M	09/03/91	M991-23P	Perimeter area	0	0	1538
M	09/03/91	M991-24P	Perimeter area	0	0	1439
M	09/03/91	M991-25P	Perimeter area	0	0	1330

(continued)

APPENDIX A (continued)

Site	Sample date	Sample number	Sampling locataion	Concentration s/cm³	Concentration s/mm²	Air Volume, L
N	04/29/91	N91-11-A	Previously abated area	0.009	47	2099
N	04/29/91	N91-12-A	Previously abated area	0.003	16	2112
N	04/29/91	N91-13-A	Previously abated area	0.003	16	2018
N	04/29/91	N91-14-A	Previously abated area	0.003	16	2059
N	04/29/91	N91-15-A	Previously abated area	0.003	16	2000
N	04/29/91	N91-06-P	Perimeter area	0.012	63	2018
N	04/29/91	N91-07-P	Perimeter area	0.015	78	2018
N	04/29/91	N91-08-P	Perimeter area	0.003	16	1978
N	04/29/91	N91-08-PR	Replicate of N91-08-P	0	0	1978
N	04/29/91	N91-09-P	Perimeter area	0	0	1984
N	04/29/91	N91-10-P	Perimeter area	0.046	203	1717
N	08/14/91	N-891-11A	Previously abated area	0	0	1311
N	08/14/91	N-891-12A	Previously abated area	0	0	1469
N	08/14/91	N-891-13A	Previously abated area	0	0	1335
N	08/14/91	N-891-14A	Previously abated area	0	0	1325
N	08/14/91	N-891-15A	Previously abated area	0.013	54	1590
N	08/14/91	N-891-06P	Perimeter area	0	0	1383
N	08/14/91	N-891-07P	Perimeter area	0	0	1385
N	08/14/91	N-891-08P	Perimeter area	0.005	18	1445
N	08/14/91	N-891-09P	Perimeter area	0.005	18	1454
N	08/14/91	N-891-10P	Perimeter area	0	0	1437
O	05/08/91	O91-11-A	Previously abated area	0.022	125	2163
O	05/08/91	O91-11-AD	Duplicate of O91-11-A	0.010	54	2163
O	05/08/91	O91-12-A	Previously abated area	0	0	2152
O	05/08/91	O91-13-A	Previously abated area	0	0	2170
O	05/08/91	O91-14-A	Previously abated area	0	0	2140
O	05/08/91	O91-15-A	Previously abated area	0.003	18	2134
O	05/08/91	O91-01-O	Outdoors	0	0	2105
O	05/08/91	O91-02-O	Outdoors	0	0	2123
O	05/08/91	O91-03-O	Outdoors	0	0	2099
O	05/08/91	O91-04-O	Outdoors	0.003	18	2093
O	05/08/91	O91-05-O	Outdoors	0.003	18	2111
O	05/08/91	O91-06-P	Perimeter area	0	0	2204
O	05/08/91	O91-07-P	Perimeter area	0	0	2174
O	05/08/91	O91-07-PR	Replicate of O91-07-P	0	0	2174
O	05/08/91	O91-08-P	Perimeter area	0	0	2187
O	05/08/91	O91-09-P	Perimeter area	0	0	2147
O	05/08/91	O91-10-P	Perimeter area	0	0	2184
P	05/08/91	P91-11-A	Previously abated area	0.004	18	1812
P	05/08/91	P91-12-A	Previously abated area	0.004	18	1752
P	05/08/91	P91-13-A	Previously abated area	0	0	1806
P	05/08/91	P91-14-A	Previously abated area	0.011	54	1872
P	05/08/91	P91-15-A	Previously abated area	0	0	1866
P	05/08/91	P91-01-O	Outdoors	0	0	1806
P	05/08/91	P91-02-O	Outdoors	0	0	1812
P	05/08/91	P91-03-O	Outdoors	0	0	1800
P	05/08/91	P91-04-O	Outdoors	0	0	1800
P	05/08/91	P91-05-O	Outdoors	0	0	1806
P	05/08/91	P91-06-P	Perimeter area	0	0	1824
P	05/08/91	P91-07-P	Perimeter area	0	0	1824
P	05/08/91	P91-08-P	Perimeter area	0.004	18	1860
P	05/08/91	P91-09-P	Perimeter area	0	0	1836
P	05/08/91	P91-09-PR	Replicate of P91-09-P	0.004	18	1836
P	05/08/91	P91-10-P	Perimeter area	0	0	1805
Q	05/09/91	Q91-11-A	Previously abated area	0.010	54	2010
Q	05/09/91	Q91-12-A	Previously abated area	0	0	1998
Q	05/09/91	Q91-13-A	Previously abated area	0.007	36	1953

(continued)

APPENDIX A (continued)

Site	Sample date	Sample number	Sampling locataion	Concentration s/cm³	Concentration s/mm²	Air Volume, L
Q	05/09/91	Q91-14-A	Previously abated area	0.010	54	1968
Q	05/09/91	Q91-15-A	Previously abated area	0.018	89	1956
Q	08/13/91	Q-891-11A	Previously abated area	0.005	18	1356
Q	08/13/91	Q-891-12A	Previously abated area	0.005	18	1453
Q	08/13/91	Q-891-13A	Previously abated area	0.005	18	1391
Q	08/13/91	Q-891-14A	Previously abated area	0.005	18	1462
Q	08/13/91	Q-891-15A	Previously abated area	0.005	18	1436
R	05/02/91	R91-11-A	Previously abated area	0.010	54	2012
R	05/02/91	R91-12-A	Previously abated area	0.003	18	2007
R	05/02/91	R91-13-A	Previously abated area	0.003	18	1995
R	05/02/91	R91-13-AR	Replicate of R91-13-A	0.003	18	1995
R	05/02/91	R91-14-A	Previously abated area	0	0	1989
R	05/02/91	R91-15-A	Previously abated area	0.007	36	2007
R	05/02/91	R91-01-O	Outdoors	0.003	16	2024
R	05/02/91	R91-02-O	Outdoors	0.003	16	2048
R	05/02/91	R91-03-O	Outdoors	0.012	63	2036
R	05/02/91	R91-04-O	Outdoors	0	0	2007
R	05/02/91	R91-05-O	Outdoors	0	0	2013
R	05/02/91	R91-06-P	Perimeter area	0	0	2007
R	05/02/91	R91-07-P	Perimeter area	0.004	18	1955
R	05/02/91	R91-08-P	Perimeter area	0	0	1995
R	05/02/91	R91-09-P	Perimeter area	0	0	1995
R	05/02/91	R91-10-P	Perimeter area	0.003	18	2053
S	05/02/91	S91-11-A	Previously abated area	0	0	1785
S	05/02/91	S91-11-AR	Replicate of S91-11-A	0.008	36	1785
S	05/02/91	S91-12-A	Previously abated area	0	0	1900
S	05/02/91	S91-13-A	Previously abated area	0.004	18	1853
S	05/02/91	S91-14-A	Previously abated area	0	0	1841
S	05/02/91	S91-15-A	Previously abated area	0	0	1829
S	05/02/91	S91-01-O	Outdoors	0.004	16	1662
S	05/02/91	S91-02-O	Outdoors	0	0	1647
S	05/02/91	S91-03-O	Outdoors	0	0	1691
S	05/02/91	S91-04-O	Outdoors	0	0	1691
S	05/02/91	S91-05-O	Outdoors	0	0	1898
S	05/02/91	S91-06-P	Perimeter area	0	0	1852
S	05/02/91	S91-07-P	Perimeter area	0.004	18	1801
S	05/02/91	S91-08-P	Perimeter area	0	0	1830
S	05/02/91	S91-09-P	Perimeter area	0	0	1841
S	05/02/91	S91-10-P	Perimeter area	0.011	54	1840
T	05/03/91	T91-11-A	Previously abated area	0	0	1919
T	05/03/91	T91-12-A	Previously abated area	0	0	1902
T	05/03/91	T91-13-A	Previously abated area	0	0	1959
T	05/03/91	T91-14-A	Previously abated area	0	0	1952
T	05/03/91	T91-15-A	Previously abated area	0.007	36	1935
T	05/03/91	T91-15-AR	Replicate of T91-15-A	0	0	1935
T	05/03/91	T91-01-0	Outdoors	0	0	1931
T	05/03/91	T91-02-0	Outdoors	0	0	1931
T	05/03/91	T91-03-O	Outdoors	0	0	1931
T	05/03/91	T91-04-O	Outdoors	0	0	1931
T	05/03/91	T91-05-O	Outdoors	0	0	1958
T	05/03/91	T91-05-OD	Duplicate of T91-05-O	0	0	1958
T	05/03/91	T91-06-P	Perimeter area	0	0	1965
T	05/03/91	T91-07-P	Perimeter area	0	0	1925
T	05/03/91	T91-08-P	Perimeter area	0.004	18	1925
T	05/03/91	T91-09-P	Perimeter area	0.004	18	1908
T	05/03/91	T91-10-P	Perimeter area	0	0	1919

APPENDIX B

STRUCTURE TYPE AND MORPHOLOGY DISTRIBUTIONS FOR SITES A THROUGH T

APPENDIX B
STRUCTURE TYPE AND MORPHOLOGY DISTRIBUTIONS FOR SITES A THROUGH T

Site	Sampling Location	Number of Structures	Type of Asbestos		Structure Morphology			
			% Chrysotile	% Amphibole	% Fibers	% Bundles	% Clusters	% Matrices
A	Previously abated area	1	100	0	100	0	0	0
	Perimeter	6	83.3	16.7	100	0	0	0
	Outdoors	6	100	0	100	0	0	0
B	Previously abated area	40	100	0	97.5	0	0	2.5
	Perimeter	17	100	0	88.2	0	0	11.8
	Outdoors	1	100	0	100	0	0	0
C	Previously abated area	8	100	0	75	12.5	0	12.5
	Perimeter	1	100	0	100	0	0	0
	Outdoors	6	100	0	83.3	0	0	16.7
D	Previously abated area	33	100	0	87.9	3.0	3.0	6.1
	Perimeter	8	100	0	50.0	12.5	0	37.5
	Outdoors	7	100	0	57.1	0	0	42.9
E	Previously abated area	54	98.1	1.9	13.0	1.9	16.7	68.5
	Perimeter	14	100	0	50	7.1	0	42.9
	Outdoors	5	100	0	100	0	0	0

(continued)

APPENDIX B (continued)

Site	Sampling Location	Number of Structures	Type of Asbestos		Structure Morphology			
			% Chrysotile	% Amphibole	% Fibers	% Bundles	% Clusters	% Matrices
F	Previously abated area	61	100	0	34.4	16.4	4.9	44.3
	Perimeter	52	100	0	25	7.7	3.8	63.5
	Outdoors	1	100	0	100	0	0	0
G	Previously abated area	37	100	0	94.6	0	0	5.4
	Perimeter	7	100	0	57.1	0	0	42.9
	Outdoors	2	100	0	100	0	0	0
H	Previously abated area	7	100	0	57.1	14.3	14.3	14.3
	Perimeter	10	100	0	80	0	0	20
	Outdoors	5	100	0	80	0	0	20
I	Previously abated area	4	100	0	75	0	0	25
	Perimeter	7	100	0	100	0	0	0
	Outdoors	6	100	0	83.3	0	0	16.7
J	Previously abated area	4	100	0	100	0	0	0
	Perimeter	0	-	-	-	-	-	-
	Outdoors	1	100	0	100	0	0	0

(continued)

APPENDIX B (continued)

Site	Sampling Location	Number of Structures	Type of Asbestos		Structure Morphology			
			% Chrysotile	% Amphibole	% Fibers	% Bundles	% Clusters	% Matrices
K	Previously abated area	44	100	0	90.9	0	0	9.1
	Perimeter	5	100	0	100	0	0	0
	Outdoors	0	-	-	-	-	-	-
L	Previously abated area	10	100	0	10	10	0	80
	Perimeter	5	100	0	0	0	20	80
	Outdoors	0	-	-	-	-	-	-
M	Previously abated area	37	100	0	86.5	0	0	13.5
	Perimeter	5	100	0	80	0	0	20
	Outdoors	6	100	0	83.3	0	0	16.7
N	Previously abated area	7	100	0	71.4	14.3	0	14.3
	Perimeter	23	100	0	78.3	0	0	21.7
	Outdoors	0	-	-	-	-	-	-
O	Previously abated area	8	100	0	100	0	0	0
	Perimeter	0	-	-	-	-	-	-
	Outdoors	2	100	0	100	0	0	0

(continued)

APPENDIX B (continued)

Site	Sampling Location	Number of Structures	Type of Asbestos		Structure Morphology			
			% Chrysotile	% Amphibole	% Fibers	% Bundles	% Clusters	% Matrices
P	Previously abated area	5	100	0	20	0	0	80
	Perimeter	1	100	0	0	0	100	0
	Outdoors	0	-	-	-	-	0	-
Q	Previously abated area	13	100	0	92.3	0	0	7.7
	Perimeter	17	100	0	88.2	0	0	11.8
	Outdoors	1	100	0	100	0	0	0
R	Previously abated area	7	100	0	100	0	0	0
	Perimeter	2	100	0	100	0	0	0
	Outdoors	6	100	0	83.3	0	0	16.7
S	Previously abated area	1	100	0	0	0	0	100
	Perimeter	4	100	0	100	0	0	0
	Outdoors	1	100	0	100	0	0	0
T	Previously abated area	2	100	0	100	0	0	0
	Perimeter	2	100	0	100	0	0	0
	Outdoors	0	-	-	-	-	-	-

APPENDIX C

PHASE III CASE HISTORIES

PHASE III CASE HISTORY
SITES B AND Q

Background

During the summer of 1988, two asbestos abatement projects were conducted at this school (Sites B and Q). Sprayed-applied acoustical ceiling plaster was removed from the second floor (Site B) and from the first floor (Site Q). At both sites the abatement area included corridors, classrooms, and offices. The ceiling plaster contained approximately 2 to 6 percent chrysotile asbestos. The information regarding the abated ACM and associated asbestos-content was obtained from the asbestos-abatement specification for these sites. No additional abatement activity occurred between 1988 and 1991.

Summary of Phase III Air Monitoring Data

Site B

On May 9, 1991, EPA/NJDOH collected air samples during periods of normal activity (i.e., occupied conditions) at Site B from the same locations as previous samples collected in 1988 and 1990. Table C-1 presents the results of the May 9 sampling. Since the average airborne asbestos concentration (0.027 s/cm^3) exceeded 0.02 s/cm^3 in the previously abated area, EPA/NJDOH conducted follow-up monitoring under simulated occupancy conditions on August 13, 1991, to determine whether airborne asbestos was still present at levels similar to those measured in May 1991. Table C-2 presents the results of the August 13 sampling. The August 13 results revealed an average airborne asbestos concentration in the previously abated area was less than 0.02 s/cm^3 (0.018 s/cm^3); therefore, no further monitoring activity was required at this school. Intervention continued in order to resolve the elevated asbestos concentrations at this site.

TABLE C-1. RESULTS OF MAY 9, 1991, AIR MONITORING AT SITE B

Airborne asbestos concentration, s/cm^3		
Previously abated area	Perimeter area	Outdoors
0.014	0.014	0
0.044	0.011	0
0.014	0.004	0
0.055	0.007	0.004
0.010	0.024	0
Average: 0.027	Average: 0.012	Average: 0.001

TABLE C-2. RESULTS OF AUGUST 13, 1991, AIR MONITORING AT SITE B

Airborne asbestos concentration, s/cm^3		
Previously abated area	Perimeter area	Outdoors
0.013	0	0.005
0.009	0.005	0
0.064	0	0
0	0	0
0.004	0	0
Average: 0.018	Average: 0.001	Average: 0.001

Site Q

On May 9, 1991, EPA/NJDOH collected air samples during periods of normal activity (i.e., occupied conditions) at Site Q from the same locations as the samples collected in 1988 and 1990. Table C-3 presents the results of the May 9 sampling.

Although the average airborne asbestos concentration in the previously abated area and the perimeter area did not exceed 0.02 s/cm^3, EPA/NJDOH conducted follow-up monitoring on August 13, 1991, under simulated occupancy conditions because the average airborne asbestos concentration in the previously abated area from a second abatement project at this school (Site B) did exceed 0.02 s/cm^3. Table C-4 presents the results of the August 13 sampling. The August 13 results showed that the average airborne asbestos concentration in the previously abated area and perimeter areas of Site Q were below 0.02 s/cm^3; therefore, no further monitoring activity was required.

NJDOH Visual Inspection

On August 14, 1991, a NJDOH Visual Inspection was conducted at Sites B and Q to determine potential sources of airborne asbestos measured by EPA and NJDOH in May 1991. The visual inspection strategy considered the asbestos-abatement history of the site, the operations and maintenance (O&M) activities, and other sources of possible asbestos contamination (i.e., materials not included in the Asbestos Management Plan). Only those areas indicated in the following subsections were examined by the NJDOH inspector in August 1991.

1988 Abatement Areas

Second Floor Classrooms--Two samples of overspray and debris were obtained from the structural steel and closet overhead areas (Table C-5). These samples tested positive for chrysotile asbestos. All areas examined showed signs of inadequate encapsulation.

TABLE C-3. RESULTS OF MAY 9, 1991, AIR MONITORING AT SITE Q

Airborne asbestos concentration, s/cm^3		
Previously abated area	Perimeter area[a]	Outdoors[a]
0.010	0.014	0
0	0.011	0
0.007	0.004	0
0.010	0.007	0.004
0.018	0.024	0
Average: 0.009	Average: 0.012	Average: 0.001

[a] Same samples as collected at Site B.

TABLE C-4. RESULTS OF AUGUST 13, 1991, AIR MONITORING AT SITE Q

Airborne asbestos concentration, s/cm^3		
Previously abated area	Perimeter area[a]	Outdoors[a]
0.005	0	0.005
0.005	0.005	0
0.005	0	0
0.005	0	0
0.013	0	0
Average: 0.005	Average: 0.001	Average: 0.001

[a] Same samples as collected at Site B.

TABLE C-5. SUMMARY OF BULK SAMPLE RESULTS--SITES B AND Q REINSPECTION

Location	Type of material	Analysis
1988 Abatement Area		
2nd floor classroom, closet overhead, truss	Flakes of spray-on debris	Positive[a], chrysotile asbestos
2nd floor classroom, top of closet	Flakes of spray-on debris	Positive, chrysotile asbestos
1st floor classroom	Flakes of spray-on debris	Positive, chrysotile asbestos
1st floor classroom, air shaft ledge	Flakes of spray-on debris	Negative
1988 Perimeter Areas		
Basement all-purpose room	Composite, ceiling sample	Negative

[a] This classification was defined by the NJDOH laboratory to accommodate samples of which there is not adequate material available to allow a full quantitative evaluation, but are of sufficient size to determine that asbestos is present and to determine the specific type of asbestos. Based on the professional judgement of the analyst, the sample is considered to contain greater than 1% asbestos.

First Floor Classrooms--Conditions regarding overspray and debris were the same as those noted in the second floor classrooms. Two samples were collected (Table C-5); one sample of spray-on debris tested positive for chrysotile asbestos. A sample of sandy debris from an air shaft tested negative for asbestos.

1988 Perimeter Areas

In the basement all-purpose room, thermal system insulation (TSI) not identified in the Asbestos Management Plan was observed in the ceiling overhead spaces in the

corridor, kitchen, and storage closet. This material appeared to be in generally good condition.

Conclusions

Incomplete assessment and abatement failed to account for overspray in the ceiling overhead spaces and the closet recessions. These asbestos-containing materials could have contributed to the elevated airborne asbestos levels measured in May 1991.

PHASE III CASE HISTORY
SITES C AND M

Background

During the summer of 1988, two asbestos abatement projects were conducted at this school (Sites C and M). At Site C, asbestos-containing thermal system insulation (TSI) was removed from a boiler, water tank, fan duct, and pipes in the boiler room located in the basement and from pipes in the corridor adjacent to the boiler room. At Site M, TSI was removed from pipes in the corridors, classroom, office, storage room, and gymnasium located in the basement. The TSI contained approximately 40 to 60 percent chrysotile asbestos. The information regarding the abated ACM and associated asbestos-content was obtained from the asbestos-abatement specification for these sites. There has been no additional abatement activity between 1988 and 1991.

Summary of Phase III Air Monitoring Data

Site C

On May 1, 1991, EPA/NJDOH collected air samples during periods of normal activity (i.e., occupied conditions) at Site C in the same locations as previous samples collected in 1988 and 1990. Table C-6 presents the results of the May 1 sampling. Since the average airborne asbestos concentrations in the previously abated area (0.005 s/cm^3) and in the perimeter areas (0.001 s/cm^3) did not exceed 0.02 s/cm^3, no further monitoring activity was required at this site.

Site M

On May 1, 1991, EPA/NJDOH collected air samples during periods of normal activity (i.e., occupied conditions) at Site M in the same locations as those collected in 1988 and 1990. Table C-7 presents the results of the May 1 sampling. Since the average airborne asbestos concentration in the previously abated area (0.023 s/cm^3) exceeded 0.02 s/cm^3, EPA/NJDOH conducted follow-up monitoring on August 13,

1991, under simulated occupancy conditions, to determine whether the airborne asbestos was still present at levels similar to those measured in May 1991. Table C-8 presents the results of the August 13 sampling. The average airborne asbestos concentrations in the previously abated area (0.033 s/cm^3) still exceeded 0.02 s/cm^3; therefore, NJDOH directed the school to initiate a response action to reduce the airborne asbestos concentrations in the previously abated area. The school subsequently employed a licensed asbestos abatement contractor to clean these areas.

When the response action was complete, EPA/NJDOH conducted follow-up air monitoring on August 29, 1991, to determine the residual levels of airborne asbestos. Table C-9 presents the results of the August 29 sampling. Although the average airborne asbestos concentrations in the previously abated area (0.001 s/cm^3) was below 0.02 s/cm^3, the average concentration in the perimeter area (0.029 s/cm^3) exceeded 0.02 s/cm^3; therefore, NJDOH directed the school to reclean the perimeter areas. After the second response action, NJDOH collected additional samples on September 3, 1991, in the previously abated area and the perimeter area. Average airborne asbestos concentrations in the previously abated area (0.005 s/cm^3, N=2) and the perimeter area (0 s/cm^3, N=8) were both below 0.02 s/cm^3; therefore, no further action was required at this site. Intervention continued in order to resolve the elevated asbestos concentrations at this site.

NJDOH Visual Inspection

On August 14, 1991, a NJDOH Visual Inspection was conducted at Sites C and M to determine potential sources of airborne asbestos measured by EPA/NJDOH in May 1991. The visual inspection strategy considered the asbestos-abatement history of the site, the O&M activities, and other sources of possible asbestos contamination (i.e., materials not included in the Asbestos Management Plan). Only those areas indicated in the following subsections were examined.

TABLE C-6. RESULTS OF MAY 1, 1991, AIR MONITORING AT SITE C

Airborne asbestos concentration, s/cm^3		
Previously abated area	Perimeter area	Outdoors
0.012	0	0
0	0.003	0
0.003	0	0.007
0.009	0	0.005
0	0	0.002
Average: 0.005	Average: 0.001	Average: 0.003

TABLE C-7. RESULTS OF MAY 1, 1991, AIR MONITORING AT SITE M

Airborne asbestos concentration, s/cm^3		
Previously abated area	Perimeter area	Outdoors
0.056	0.007	0
0.038	0.004	0
0.019	0.007	0.007
0.003	0	0.005
0	-	0.002
Average: 0.023	Average: 0.004	Average: 0.003

TABLE C-8. RESULTS OF AUGUST 13, 1991, AIR MONITORING AT SITE M

Airborne asbestos concentration, s/cm^3		
Previously abated area	Perimeter area	Outdoors
0.008	0	0
0.082	0	0
0.018	0.025	0
0.009	0.008	0
0.046	0.031	0.004
Average: 0.033	Average: 0.013	Average: 0.001

TABLE C-9. RESULTS OF AUGUST 29, 1991, AIR MONITORING AT SITE M

Airborne asbestos concentration, s/cm^3		
Previously abated area	Perimeter area	Outdoors
0	0	0
0	0	0
0	0.025	0
0.005	0.008	0
0	0.031	0
Average: 0.001	Average: 0.029	Average: 0

1988 Abatement Areas

Classroom, Small Gymnasium, and Corridors

No TSI debris was found in these abatement areas. Plaster debris from the wall and ceiling surfaces was evident in many areas. Top-coat plaster from the recreation room and hallway did not test positive for asbestos; however, the browncoat underlay in the adjoining hallway showed trace amounts of chrysotile asbestos (Table C-10). The storage and office areas were locked and could not be accessed.

TABLE C-10. SUMMARY OF BULK SAMPLE RESULTS--SITES C AND M REINSPECTION

Location	Type of material	Analysis
1988 Abatement Area		
Basement recreation room/classroom	Plaster, top coat	Negative
Basement hallway	Plaster, top coat	Negative
Basement hallway	Plaster, browncoat	Positive[a], chrysotile asbestos
1988 Perimeter Area		
Boiler room, coal area	Debris mixed in coal	3% chrysotile, 19% amosite, positive, crocidolite asbestos
Boiler room, coal area	TSI debris	Positive, chrysotile asbestos
Boiler room, under stairs	TSI debris	67% chrysotile asbestos

[a] This classification was defined by the NJDOH laboratory to accommodate samples of which there is not adequate material available to allow a full quantitative evaluation, but are of sufficient size to determine that asbestos is present and to determine the specific type of asbestos. Based on the professional judgement of the analyst, the sample is considered to contain greater than 1% asbestos.

1988 Perimeter Area

Boiler Room

Miscellaneous debris mixed in with the coal tested positive for chrysotile (19%), amosite (3%), and crocidolite (trace) asbestos (Table C-10). The TSI debris mixed in with the coal tested positive for chrysotile asbestos. The TSI debris found under the boiler room stairway tested positive for chrysotile asbestos (67%).

Large Gymnasium

Plaster dust and debris from renovation work were widespread along the north wall. No samples of the plaster dust were collected.

Other Considerations

The School's Asbestos Management Plan identified plaster as an asbestos-containing building material (ACBM). Samples taken by the NJDOH were reported as either 1% chrysotile asbestos, <1% chrysotile asbestos, or as negative for asbestos (Table C-10). Although none of these materials tested greater than 1% asbestos, the Asbestos Management Plan classified them as friable surfacing materials with damage and indicated that repairs would be made by September 1, 1989. At the time of the NJDOH inspection, no repairs had been made, however, the plaster debris on the floor surfaces in the large gymnasium had been cleaned up.

Conclusions

The deterioration of the plaster in the building and activities involved in the renovation and repair of the plaster may have contributed to the elevated concentrations of airborne asbestos measured in May 1991.

PHASE III CASE HISTORY
SITE D

Background

During the summer of 1988, this school underwent the removal of sprayed-on ceiling material and thermal system insulation (TSI) from the boiler room and adjoining mechanical spaces. The spray-on ceiling material was removed from the boiler room, mechanical equipment room, and electrical equipment room and adjacent corridor. The TSI was removed from a water tank and pipes in the boiler room. The spray-on ceiling material and TSI contained approximately 20 to 35 percent chrysotile asbestos and 40 to 60 percent chrysotile asbestos, respectively. In 1990, 20 square feet of TSI was removed from a vertical conveyor shaft. The information regarding the abated ACM and associated asbestos-content was obtained from the asbestos-abatement specification for this site. No other asbestos-containing material was abated between 1988 and 1991.

Summary of Phase III Air Monitoring Data

On April 30, 1991, EPA/NJDOH collected air samples during periods of normal activity (i.e., occupied conditions) at Site D from the same locations as previous samples collected in 1988 and 1990. Table C-11 presents the results of the April 30 sampling. Since the average airborne asbestos concentration in the previously abated area was 0.02 s/cm^3, EPA/NJDOH conducted follow-up monitoring under simulated occupancy conditions on August 13, 1991, to determine whether airborne asbestos was still present at levels similar to those measured in April 1991. Table C-12 presents the results of the August 13 sampling. The August 13 results revealed an average airborne asbestos concentration in the previously abated area was less than 0.02 s/cm^3 (0.018 s/cm^3); therefore, no further monitoring activity was required at this site. Intervention continued in order to resolve the elevated asbestos concentrations at this site.

TABLE C-11. RESULTS OF APRIL 30, 1991, AIR MONITORING AT SITE D

Airborne asbestos concentration, s/cm^3		
Previously abated area	Perimeter area	Outdoors
0.012	0.008	0.003
0.059	0.003	0.012
0.006	0	0.002
0.020	0.009	0.003
0.003	0.003	0
Average: 0.020	Average: 0.004	Average: 0.004

TABLE C-12. RESULTS OF AUGUST 13, 1991, AIR MONITORING AT SITE D

Airborne asbestos concentration, s/cm^3		
Previously abated area	Perimeter area	Outdoors
0	0	0.005
0.058	0	0
0.010	0	0
0.014	0	0
0	0	0
Average: 0.016	Average: 0	Average: 0.001

NJDOH Visual Inspection

On August 14, 1991, a NJDOH Visual Inspection was conducted at Site D to determine potential sources of airborne asbestos measured by EPA/NJDOH in April 1991. The visual inspection strategy considered the asbestos-abatement history of the site, the O&M activities, and other sources of possible asbestos contamination (i.e., materials not included in the Asbestos Management Plan). Only those areas indicated in the following subsections were examined.

1988 Abatement Area

Electrical Room

Ceiling debris (17% chrysotile asbestos) was present on the top of ductwork, electrical boxes, and wiring and in wall penetrations (Table C-13).

Generator Room

Ceiling debris (8 to 15% chrysotile asbestos) was present on the top of the ventilation ducts and the generator exhaust box and on the floors (Table C-13).

Boiler Room

Ceiling debris (17% chrysotile asbestos) was present on the lower window ledge areas. The ladders provided were too unstable to safely access such areas as the top of the air-handling unit and pipes (Table C-13).

Boiler Storage Room

Numerous 5-lb cans of asbestos sealant were noted in this area. These materials were due to be removed from inventory in 1989.

Corridor at the Electrical Room

The top of the suspended ceiling system was heavily contaminated with ceiling debris (18% chrysotile asbestos) (Table C-13). The wires, pipes, and ductwork in this space were covered with loose spray-on ceiling debris.

TABLE C-13. SUMMARY OF BULK SAMPLE RESULTS--SITE D REINSPECTION

Location	Type of material	Analysis
1988 Abatement Area		
Electrical room	Top of electrical box	17% chrysotile asbestos
Electrical room	Top of fire alarm box	Positive[a] for chrysotile asbestos
Basement hallway at electrical room	Top of ceiling tile	18% chrysotile asbestos
Boiler room	Corner ledge	17% chrysotile asbestos
Generator room	Top of generator exhaust box	8% chrysotile asbestos
Generator room	Top of duct	13% chrysotile asbestos
Generator room	Floor at windows	15% chrysotile asbestos

[a] This classification was defined by the NJDOH laboratory to accommodate samples of which there is not adequate material available to allow a full quantitative evaluation, but are of sufficient size to determine that asbestos is present and to determine the specific type of asbestos. Based on the professional judgement of the analyst, the sample is considered to contain greater than 1% asbestos.

1988 Perimeter Areas

Time limitations prevented the inspection of these areas.

Other Considerations

The crawl space area in the boiler room was locked at the time of the inspection; however, in a gap between the wall and the deck of the boiler area, stored thermal system insulation with extensive water damage was noted. Opening the boiler room windows or activating the boiler air feeds could have caused sufficient air movement to possibly disturb these damaged materials. The School's Asbestos Management Plan indicated that these areas were scheduled for abatement in 1989, however, at the time of the inspection no abatement had occurred.

Conclusions

A likely source of the elevated airborne asbestos concentrations measured in May 1991 was the wide-spread spray-on ceiling dust and debris throughout the abatement areas. The debris found on top of the corridor ceilings and on the various equipment and ducts could indicate that the areas were not precleaned before erection of the polyethylene containment barriers.

Damaged material in the crawl space also may have contributed to the elevated asbestos levels. All other areas of the school, such as the loading dock, dumb waiter, book storage, etc. was recommended by NJDOH to be inspected for abatement residue, dust and debris.

PHASE III CASE HISTORY
SITE E

Background

During the summer of 1988, 2-ft by 4-ft lay-in ceiling tiles and thermal system insulation (TSI) on pipes were removed from this school. The ceiling tiles were removed from classrooms, offices, and recreational areas; the TSI was removed from corridors, boiler and breech. The ceiling tiles and TSI contained trace to 1 percent amosite and 2 to 7 percent chrysotile asbestos, respectively. The information regarding the abated ACM and associated asbestos-content was obtained from the asbestos-abatement specification for this site. No additional abatement activity occurred between 1988 and 1991.

Summary of 1991 (Phase III) Air Monitoring Data

On May 6, 1991, EPA/NJDOH collected air samples during periods of normal activity (i.e., occupied conditions) at Site E from the same locations as those collected in 1988 and 1990. Table C-14 presents the results of the May 6 sampling. Since the average airborne asbestos concentration in the previously abated area (0.037 s/cm^3) exceeded 0.02 s/cm^3, EPA/NJDOH conducted follow-up monitoring under simulated occupancy conditions on August 12, 1991, to determine whether airborne asbestos was still present at levels similar to those measured in May 1991. Table C-15 presents the results of the August 12 sampling. The August 12 results revealed that the average airborne asbestos concentration in the previously abated area was less than 0.02 s/cm^3 (0.005 s/cm^3); therefore, no further monitoring activity was required at this school. Intervention continued in order to resolve the elevated airborne asbestos concentrations at this site.

NJDOH Visual Inspection

On August 13, 1991, an NJDOH Visual Inspection was conducted at Site E to determine potential sources of airborne asbestos measured by EPA/NJDOH in May

1991. The visual inspection strategy considered the asbestos-abatement history of the site, the O&M activities, and other sources of possible asbestos contamination (i.e., materials not included in the Asbestos Management Plan). Only those areas indicated in the following subsections were examined.

TABLE C-14. RESULTS OF MAY 6, 1991, AIR MONITORING AT SITE E

Airborne asbestos concentration, s/cm^3		
Previously abated area	Perimeter area	Outdoors
0.011	0.003	0.007
0.069	0.003	0.007
0.042	0.029	0
0.029	0.015	0.003
0.032	0	0
Average: 0.037	Average: 0.010	Average: 0.003

TABLE C-15. RESULTS OF AUGUST 12, 1991, AIR MONITORING AT SITE E

Airborne asbestos concentration, s/cm^3		
Previously abated area	Perimeter area	Outdoors
0.025	0.010	0.005
0	0	0
0	0.030	0
0	0.010	0
0	0	0
Average: 0.005	Average: 0.010	Average: 0.001

1988 Abatement Area

Corridors

The tops of the lockers contained small pieces of asbestos-containing ceiling tiles (Table C-16). At the end of each corridor (above the entry doors), an insulating barrier was constructed to separate the warm air in the corridor plenum from the cold air in the exterior foyer. The material in this barrier consisted of asbestos-containing plaster (7% chrysotile) over construction wire.

Art Storage Room

The TSI debris on top of the partition wall contained 5 percent chrysotile asbestos (Table C-16).

1988 Perimeter Areas

Boiler room

The TSI debris on the surface of the concrete-masonry block wall tested positive for asbestos (Table C-16). The TSI that remained on the interior surfaces of the "pork-chop" type boilers after abatement contained 2 to 5% chrysotile asbestos (Table C-16).

Conclusions

Asbestos-containing materials not included in the Asbestos Management Plan were found. These included a thermal insulating barrier (above the entry doors) at the end of each corridor and TSI lagging on the interior of the boiler.

The May 1991 monitoring revealed elevated concentrations of airborne asbestos. Because no amosite was present in any of the air samples, the source of the asbestos was material other than the ceiling tiles. These materials could have included unencapsulated debris from the 1988 abatement or the friable containing barrier above the entry doors.

TABLE C-16. SUMMARY OF BULK SAMPLE RESULTS--SITE E REINSPECTION

Location	Type of material	Analysis
1988 Abatement Area		
Top of lockers at Room 109	Ceiling tile	<1% amosite
Top of lockers at Room 108	Ceiling tile	Trace[a] amosite
At exit by Room 108	Above drop ceiling, Draft seal	7% chrysotile
Top of locker No. #403	Ceiling tile	1% amosite
Top of lockers at Room 111	Ceiling tile	1% amosite
Top of locker at boiler room	Ceiling tile	1% amosite
Art storage room	Partition wall, TSI debris	5% chrysotile
Perimeter Areas		
Boiler room	Lagging inside left boiler	5% chrysotile
Boiler room	Lagging inside right boiler	2% chrysotile
Boiler room	TSI debris on wall	Positive[b], chrysotile

[a] Trace = < 1% asbestos

[b] This classification was defined by the NJDOH laboratory to accommodate samples of which there is not adequate material available to allow a full quantitative evaluation, but are of sufficient size to determine that asbestos is present and to determine the specific type of asbestos. Based on the professional judgement of the analyst, the sample is considered to contain greater than 1% asbestos.

PHASE III CASE HISTORY
SITE F

Background

During the summer of 1988, thermal system insulation (TSI) on the boiler and pipes was removed from the boiler room at this school. The TSI contained approximately 30 to 40 percent chrysotile asbestos and trace to 4% amosite. The information regarding the abated ACM and associated asbestos-content was obtained from the asbestos-abatement specification for this site. No additional abatement activity occurred between 1988 and 1991.

Summary of 1991 (Phase III) Air Monitoring Data

On May 9, 1991, EPA/NJDOH collected air samples during periods of normal activity (i.e., occupied conditions) at Site F from the same locations as those collected in 1988 and 1990. Table C-17 presents the results of the May 9 sampling. Since the average airborne asbestos concentration in the previously abated area (0.043 s/cm^3) and in the perimeter area (0.036 s/cm^3) exceeded 0.02 s/cm^3, EPA/NJDOH conducted follow-up monitoring under simulated occupancy conditions on August 12, 1991, to determine whether airborne asbestos was still present at levels similar to those measured in May 1991. Table C-18 presents the results of the August 12 sampling. The average airborne asbestos concentrations in both the previously abated area (0.024 s/cm^3) and the perimeter area (0.023 s/cm^3) still exceeded 0.02 s/cm^3; therefore, NJDOH directed the school to initiate a response action to reduce the airborne asbestos concentrations in these areas. The school subsequently employed an asbestos abatement contractor to clean these areas. When the cleaning action was complete, EPA/NJDOH conducted follow-up air monitoring on August 28, 1991. Table C-19 presents the results of the August 28 sampling. The average airborne asbestos concentrations in the previously abated area and in the perimeter area were below 0.02 s/cm^3; therefore, no further monitoring activity was required at this site. Intervention continued in order to resolve the elevated asbestos concentrations at this site.

TABLE C-17. RESULTS OF MAY 9, 1991, AIR MONITORING AT SITE F

Airborne asbestos concentration, s/cm^3		
Previously abated area	Perimeter area	Outdoors
0.035	0.010	0
0.066	0.058	0
0.039	0.035	0.002
0.042	0.025	0
0.032	0.054	0
Average: 0.043	Average: 0.036	Average: 0.001

TABLE C-18. RESULTS OF AUGUST 12, 1991, AIR MONITORING AT SITE F

Airborne asbestos concentration, s/cm^3		
Previously abated area	Perimeter area	Outdoors
0.037	0.046	0
0.014	0.047	0.005
0.029	0.010	0.010
0.015	0	0.005
0.019	0.019	0
Average: 0.023	Average: 0.024	Average: 0.004

TABLE C-19. RESULTS OF AUGUST 28, 1991, AIR MONITORING AT SITE F

Airborne asbestos concentration, s/cm^3		
Previously abated area	Perimeter area	Outdoors
0	0.005	0
0	0.004	0.004
0	0.008	0
0	0	0
0	0	0
Average: 0	Average: 0.003	Average: 0.001

NJDOH Visual Inspection

On August 13, 1991, an NJDOH Visual Inspection was conducted at Site F to determine potential sources of airborne asbestos measured by EPA/NJDOH in May 1991. The visual inspection strategy considered the asbestos-abatement history of the site, the O&M activities, and other sources of possible asbestos contamination (i.e., materials not included in the Asbestos Management Plan). Only those areas indicated in the following subsections were examined.

1988 Abatement Area

Boiler Room

The boiler was found to have asbestos-containing TSI (29% chrysotile asbestos) on its interior. The asbestos-containing TSI on the exterior of the boiler had been removed, and the boiler had been reinsulated.

1988 Perimeter Areas

Hallway at the Boiler Room Entry

The School's Asbestos Management Plan indicated the presence of sprayed-on asbestos above the interlock ceiling in this area. No sprayed-on materials were noted; however, four different-sized homogeneous pipe runs were observed that were not included in the Asbestos Management Plan. The School's Asbestos Management Plan appeared to be in error regarding the types of material and their locations. Approximately 10 linear feet of this pipe insulation was torn from the pipes directly below an open roof vent.

School officials indicated that during a retrofit of the school's fire alarm system, workers had crawled through the suspended ceiling plenums to run wires. Such activity may have caused a fiber release and/or damage to the thermal materials. A roof leak and subsequent repair also may have contributed to the TSI damage.

Air Handling Unit Mechanical Rooms in Gymnasium

Thermal system insulation was removed from these areas. A thick accumulation of dust mixed with flakes of elbow debris (positive, chrysotile asbestos) was present on the air-handling unit (Table C-20). The duct sealant contained 49% chrysotile asbestos. The duct sealant had been abated in the north fan room and was only partly abated in the south air-handling room. Gouged friable sealant remained on the ducting and was not encapsulated.

Classrooms

The two classrooms farthest from the boiler area (Classrooms 42 and 43) were inspected for the presence of asbestos-containing debris. Both rooms had heater units equipped with blowers and external air exchangers. Thermal system insulation had been removed from the pipes in the closets adjoining these units. Asbestos-containing debris (30 to 36% chrysotile and Trace to 4% amosite) was recovered from the base of the units (Table C-20).

TABLE C-20. SUMMARY OF BULK SAMPLE RESULTS--SITE F REINSPECTION

Location	Type of material	Analysis
1988 Abatement Area		
Boiler room	Interior of Boiler 24	29% chrysotile asbestos
1988 Perimeter Areas		
S/E air handling room, gymnasium	Debris on top of air handler	Positive[a], chrysotile asbestos
S/E air handling room, gymnasium	Remaining duct sealant	49% chrysotile asbestos
Classroom 42	TSI debris in closet under heating unit	30% chrysotile asbestos 4% amosite asbestos
Classroom 43	TSI debris in closet under heating unit	36% chrysotile asbestos Trace[b], amosite asbestos

[a] This classification was defined by the NJDOH laboratory to accommodate samples of which there is not adequate material available to allow a full quantitative evaluation, but are of sufficient size to determine that asbestos is present and to determine the specific type of asbestos. Based on the professional judgement of the analyst, the sample is considered to contain greater than 1% asbestos.

[b] Trace = < 1% asbestos.

Conclusions

- The School's Asbestos Management Plan did not reflect the residual asbestos in the boilers. It was likely that this material would be disturbed during cleaning by aggressive brushing and vacuuming of the interior to remove the carbonaceous deposits.

- The Asbestos Management Plan was in error regarding the types of materials above the hallway at the boiler room entry. The 10-ft. of severely damaged TSI resulting from a roof leak along with the installation of electrical cable in the plenum above the hallway may have resulted in a release of asbestos fibers from the damaged TSI.

- The asbestos-containing TSI debris collected in the air-handling rooms and classrooms indicated that these areas may have been contaminated as the result of incomplete abatement action. The asbestos-containing debris may have been reentrained by the air handling system or the normal activity of building occupants.

PHASE III CASE HISTORY
SITE G

Background

During the summer of 1988, thermal system insulation (TSI) was removed from the boiler room at this school (Site G). The abatement included removal of boiler lagging (10 to 15% chrysotile and 35 to 40% amosite), boiler breeching (25 to 30% chrysotile and 30 to 35% amosite), and the boiler gasket (70 to 75% chrysotile). The information regarding the abated ACM and associated asbestos-content was obtained from the asbestos-abatement specification for this site. No additional abatement activity occurred between 1988 and 1991.

Summary of 1991 (Phase III) Air Monitoring Data

On May 3, 1991, EPA/NJDOH collected air samples during periods of normal activity (i.e., occupied conditions) at Site G from the same locations as those collected in 1988 and 1990. Table C-25 presents the results of the May 3 sampling. Since the average airborne asbestos concentration in the previously abated area (0.027 s/cm^3) exceeded 0.02 s/cm^3, EPA/NJDOH conducted follow-up monitoring under simulated occupancy conditions on August 14, 1991, to determine whether airborne asbestos was still present in the concentrations measured in May 1991. Table C-26 presents the results of the August 14 sampling. The average airborne asbestos concentrations in both the previously abated area (0.048 s/cm^3) and in the perimeter area (0.063 s/cm^3) exceeded 0.02 s/cm^3; therefore NJDOH directed the school to initiate a response action to reduce the airborne asbestos concentrations in these areas. The school subsequently utilized trained in-house staff to clean these areas.

When the cleaning action was complete, EPA/NJDOH conducted follow-up air monitoring on August 26, 1991, to determine the residual levels of airborne asbestos. Table C-27 presents the results of the August 26 sampling. The average airborne asbestos concentrations in the previously abated area and in the perimeter area were below 0.02 s/cm^3; therefore, no further monitoring activity was required at this school.

Intervention continued in order to resolve the elevated asbestos concentrations at this site.

TABLE C-25. RESULTS OF MAY 3, 1991, AIR MONITORING AT SITE G

Airborne asbestos concentration, s/cm^3		
Previously abated area	Perimeter area	Outdoors
0.032	0	0.003
0.025	0	0
0.011	0.011	0.004
0.030	0.007	0
0.037	0.007	0
Average: 0.027	Average: 0.005	Average: 0.001

TABLE C-26. RESULTS OF AUGUST 14, 1991, AIR MONITORING AT SITE G

Airborne asbestos concentration, s/cm^3		
Previously abated area	Perimeter area	Outdoors
0.028	0.022	0.015
0.080	0.181	0.015
0.068	0.029	0.013
0.035	0.034	0.009
0.029	0.051	0.015
Average: 0.048	Average: 0.063	Average: 0.013

TABLE C-27. RESULTS OF AUGUST 26, 1991, AIR MONITORING AT SITE G

Airborne asbestos concentration, s/cm^3		
Previously abated area	Perimeter area	Outdoors
0	0.009	0.005
0.005	0.010	0
0.044	0	0
0	0	0.004
0	0	0.015
Average: 0.01	Average: 0.004	Average: 0.005

NJDOH Visual Inspection

On August 15, 1991, a NJDOH Visual Inspection was conducted at Site G to determine potential sources of airborne asbestos concentrations measured by EPA/NJDOH in May 1991. The visual inspection strategy considered the asbestos-abatement history of the site, the O&M activities, and other sources of possible asbestos contamination (i.e., materials not included in the Asbestos Management Plan). Only those areas indicated in the following subsections were examined.

1988 Abatement Area

All areas examined revealed contamination from abatement activities. Wall penetrations, pipe hangers, tops of tanks, wiring, and electrical panels were all contaminated with residual material and debris (Table C-28).

TABLE C-28. SUMMARY OF BULK SAMPLE RESULTS--SITE G REINSPECTION

Location	Type of Material	Analysis
1988 Abatement Areas		
Boiler room	Wall, slurry at extension tank	7% Chrysotile asbestos 8% Amosite asbestos
Boiler room	Wall, slurry on conduit	8% Chrysotile asbestos 4% Amosite asbestos
Boiler room	Remaining insulation on tank	42% Chrysotile asbestos
Boiler room	Debris, top of Devlin Elec. Unit	2% Chrysotile asbestos 19% Amosite asbestos
Boiler room	Debris, brace of Devlin Unit	1% Chrysotile asbestos 25% Amosite asbestos
Boiler room	Debris, pipe hangers	34% Chrysotile asbestos
Boiler room	Debris, pipe penetration to hallway	<1% Chrysotile asbestos 18% Amosite asbestos
Boiler room	Debris, sprinkler box	3% Chrysotile asbestos 24% Amosite asbestos
Boiler room	Residue, hole in ceiling	1% Chrysotile asbestos 16% Amosite asbestos
Boiler room	Debris, pipe penetration, janitors office	2% Chrysotile asbestos 22% Amosite asbestos
Boiler room	Residue, ceiling penetration	Positive[a], amosite asbestos
1988 Perimeter Areas		
West office	Plaster and browncoat	Negative
Storage by Room 312	Plaster and browncoat	Negative
Room between 311 and 312	Plaster and browncoat	Negative
Third-floor rear corridor	Plaster and browncoat	Negative
Third-floor rear (NE) room	Insulation below floors	Negative
First-floor corridor	Blackboard slate, debris	Negative

[a] This classification was defined by the NJDOH laboratory to accommodate samples of which there is not adequate material available to allow a full quantitative evaluation, but are of sufficient size to determine that asbestos is present and to determine the specific type of asbestos. Based on the professional judgement of the analyst, the sample is considered to contain greater than 1% asbestos.

1988 Perimeter Areas

Various areas throughout the school (classrooms and offices) were undergoing renovation at the time of the inspection. Plaster walls were being demolished, which left many areas coated with plaster dust. According to the Asbestos Management Plan, one of two plaster samples tested positive (1%) for asbestos. Several samples collected during the inspection, however, showed no detectable levels of asbestos in either the top-coat or browncoat layer (Table C-28).

Conclusions

The primary source of the elevated airborne asbestos concentrations measured in May 1991 is from the residual asbestos-containing material and debris on surfaces in the boiler room remaining from the 1988 abatement.

PHASE III CASE HISTORY
SITE H

Background

During the summer of 1988, asbestos-containing acoustical ceiling material, spray-applied fireproofing, and thermal system insulation (TSI) insulation were removed from Site H. The abatement area included corridors and adjacent vestibules, classrooms, offices, and recreational rooms. The acoustical plaster, fireproofing, and TSI contained 10 to 25 percent, 25 to 50 percent, and 40 to 60 percent chrysotile asbestos, respectively. The information regarding the abated ACM and associated asbestos-content was obtained from the asbestos-abatement specification for this site. No additional abatement activity occurred between 1988 and 1991.

Summary of 1991 (Phase III) Air Monitoring Data

On April 30, 1991, EPA/NJDOH collected air samples during periods of normal activity (i.e., occupied conditions) at Site H from the same locations as those collected in 1988 and 1990. Table C-21 presents the results of the April 30 sampling. Although the average airborne asbestos concentration in the previously abated area and in the perimeter area did not exceed 0.02 s/cm^3, replicate analyses of the samples collected in the previously abated area revealed an average level above 0.02 s/cm^3. Therefore, EPA/NJDOH conducted follow-up monitoring under simulated occupancy conditions on August 15, 1991. Table C-22 presents the results of the August 15 sampling. The average airborne asbestos concentrations in the previously abated area (0.035 s/cm^3) exceeded 0.02 s/cm^3; therefore NJDOH directed the school to initiate a response action to reduce the airborne asbestos concentrations in this area. The school subsequently employed an asbestos abatement contractor to clean the previously abated and perimeter areas. When the cleaning action was complete, EPA/NJDOH conducted follow-up air monitoring on August 29, 1991, to determine the residual levels of airborne asbestos. Table C-23 presents the results of the August 29

TABLE C-21. RESULTS OF APRIL 30, 1991, AIR MONITORING AT SITE H

Airborne asbestos concentration, s/cm^3		
Previously abated area	Perimeter area	Outdoors
0.014	0.011	0
0.003	0.008	0.003
0	0	0.003
0.003	0	0.005
0	0.008	0.003
Average: 0.003	Average: 0.005	Average: 0.003

TABLE C-22. RESULTS OF AUGUST 15, 1991, AIR MONITORING AT SITE H

Airborne asbestos concentration, s/cm^3		
Previously abated area	Perimeter area	Outdoors
0.061	0.005	0
0.005	0.020	0
0.048	0	0
0.050	0.014	0
0.011	0.025	0
Average: 0.035	Average: 0.013	Average: 0

TABLE C-23. RESULTS OF AUGUST 29, 1991, AIR MONITORING AT SITE H

Airborne asbestos concentration, s/cm^3		
Previously abated area	Perimeter area	Outdoors
0.073	0	0
0	0	0
0	0	0
0	0	0
0.005	0	0
Average: 0.016	Average: 0	Average: 0

sampling. The average airborne asbestos concentrations in the previously abated area and in the perimeter area were below 0.02 s/cm^3; therefore, no further monitoring activity was required at this school. Intervention continued in order to resolve the elevated asbestos concentrations at this site.

NJDOH Visual Inspection

On August 16, 1991, a NJDOH Visual Inspection was conducted at Site H to determine potential sources of airborne asbestos measured by EPA/NJDOH in April 1991. The visual inspection strategy considered the asbestos-abatement history of the site, the O&M activities, and other sources of possible asbestos contamination (i.e., materials not included in the Asbestos Management Plan). Only those areas of the 1988 abatement indicated in the following subsections were examined.

1988 Abatement Areas

Corridor by the Shop Areas

Spray applied ceiling debris collected from the top surface of the ceiling access panels contained 7% chrysotile asbestos (Table C-24). An accumulation of dust found

TABLE C-24. SUMMARY OF BULK SAMPLE RESULTS--SITE H REINSPECTION

Location	Type of material	Analysis
1988 Abatement Area		
Drafting storage	Block pipe insulation debris	Negative
Hall at shops	Above suspended ceiling, 4-in. block pipe insulation	Negative
Hall at shops	Above suspended ceiling, elbow debris with dark spots	Negative
Hall at shops	Above suspended ceiling, 7-in. block pipe insulation with straw	Negative
Hall to gymnasium	Above suspended ceiling, elbow with dark spots	Negative
Hall to gymnasium	Above suspended ceiling, block pipe insulation with straw	Negative
Hall at shops	Radiator dust	Positive[a], chrysotile asbestos
Hall intersection (shop-cafe), access panel	Residual ceiling material	7% chrysotile asbestos
End shop, partition wall	Dust and debris	Positive, chrysotile asbestos
Drafting shop, partition wall	Ceiling debris	8% chrysotile asbestos
Drafting shop	Radiator dust	Positive, chrysotile asbestos
1988 Perimeter Area		
Hall at Custodian's office	Duct insulation	1% chrysotile asbestos 6% amosite asbestos
Auditorium stage, wall at electrical panel	Debris	35% chrysotile asbestos
Auditorium stage, by duct	Debris	27% chrysotile asbestos

[a] This classification was defined by the NJDOH laboratory to accommodate samples of which there is not adequate material available to allow a full quantitative evaluation, but are of sufficient size to determine that asbestos is present and to determine the specific type of asbestos. Based on the professional judgement of the analyst, the sample is considered to contain greater than 1% asbestos.

on the baseboard heating pipes tested positive for asbestos (Table C-24). The TSI on pipes above the ceiling did not contain asbestos (Table C-24).

Corridor to the Gymnasium

The TSI on pipes above the ceiling did not contain asbestos (Table C-24).

Mechanical Arts Shops

Metal partition walls along the windows contained ceiling debris (8% chrysotile) and dust that tested positive for asbestos (Table C-24). Radiators were also found to contain debris and dust that tested positive for chrysotile asbestos (Table C-24).

1988 Perimeter Areas

Hallway by the Custodian's Locker Room

Duct insulation above the ceiling in the hallway outside the mens custodian locker room was friable and contained 1% chrysotile and 6% amosite asbestos (Table C-24). The duct insulation was not included in the Asbestos Management Plan.

Auditorium

A fireproofing type of material adhered to several areas of the stage wall. Two samples of this material contained 27 and 35% chrysotile asbestos (Table C-24).

Conclusions

- The asbestos-containing debris and dust on ceiling panels and behind partition walls was a source of airborne asbestos fibers measured in May 1991.
- Asbestos-containing duct insulation was not identified in the Asbestos Management Plan.
- The Asbestos Management Plan erroneously identified the TSI on pipes above the corridor ceilings as asbestos-containing material.

PHASE III CASE HISTORY
SITES K AND N

Background

During the summer of 1988, asbestos-containing acoustical ceiling plaster was removed from Sites K and N. The abatement area included corridors, mechanical arts classrooms, and offices. The acoustical plaster contained 10 to 25% chrysotile asbestos. The information regarding the abated ACM and associated asbestos-content was obtained from the asbestos-abatement specification for these sites.

During the summer of 1991, 75,600 square feet of asbestos-containing ceiling plaster was abated from areas of the school unrelated to the two areas abated in 1988. No other abatement activity occurred between 1988 and 1991.

Summary of 1991 (Phase III) Air Monitoring Data

Site K

On April 29, 1991, EPA/NJDOH collected air samples during periods of normal activity (i.e., occupied conditions) at Site K from the same locations as those collected in 1988 and 1990. Table C-29 presents the results of the April 29 sampling. Since the average airborne asbestos concentration in the previously abated area (0.041 s/cm^3) exceeded 0.02 s/cm^3, EPA/NJDOH conducted follow-up monitoring under simulated occupancy conditions on August 14, 1991, to determine whether airborne asbestos was still present at levels similar to those measured in April 1991. Table C-30 presents the results of the August 14 sampling. The August 14 results revealed that the average airborne asbestos concentrations in the previously abated area and in the perimeter area were below 0.02 s/cm^3; therefore, no further monitoring activity was required at this school. Intervention continued in order to resolve the elevated asbestos concentrations at this site.

TABLE C-29. RESULTS OF APRIL 29, 1991, AIR MONITORING AT SITE K

Airborne asbestos concentration, s/cm^3		
Previously abated area	Perimeter area	Outdoors
0.097	0	0
0.014	0	0
0.022	0.006	0
0.040	0.003	0
0.033	0.007	0
Average: 0.041	Average: 0.003	Average: 0

TABLE C-30. RESULTS OF AUGUST 14, 1991, AIR MONITORING AT SITE K

Airborne asbestos concentration, s/cm^3		
Previously abated area	Perimeter area	Outdoors
0.006	0	0
0.005	0.005	0
0.005	0	0.009
0	0	0.006
0.005	0	0
Average: 0.004	Average: 0.001	Average: 0.003

Site N

On April 29, 1991, EPA/NJDOH collected air samples during periods of normal activity (i.e., occupied conditions) at Site N from the same locations as those collected in 1988 and 1990. Table C-31 presents the results of the April 29 sampling. Although the average airborne asbestos concentrations in the previously abated area and in the perimeter area did not exceed 0.02 s/cm^3, EPA/NJDOH conducted follow-up monitoring under simulated occupancy conditions on August 14, 1991, because the average airborne asbestos concentration in the previously abated area from a second abatement project at this school (Site K) did exceed 0.02 s/cm^3. Table C-32 presents the results of the August 14 sampling. The August 14 results revealed that the average airborne asbestos concentrations in the previously abated area and in perimeter areas of Site N were below 0.02 s/cm^3; therefore, no further monitoring activity was required at this site.

NJDOH Visual Inspection

On August 15, 1991, an NJDOH Visual Inspection was conducted at Sites K and N to determine potential sources of airborne asbestos measured by EPA/NJDOH in April 1991. The visual inspection strategy considered the asbestos-abatement history of the site, the O&M activities, and other sources of possible asbestos contamination (i.e., materials not included in the Asbestos Management Plan). Only those areas indicated in the following subsections were examined.

1988 Abatement Areas

Carpentry Shop and Classroom

Surface dust on building and equipment surfaces tested positive for asbestos (Table C-33). Floor tile from the carpentry classroom contained 7% chrysotile. The floor tile was not identified as ACM in the management plan. No apparent source of the asbestos-containing material associated with the 1988 abatement was identified in this area.

TABLE C-31. RESULTS OF APRIL 29, 1991, AIR MONITORING AT SITE N

Airborne asbestos concentration, s/cm^3		
Previously abated area	Perimeter area	Outdoors
0.009	0.012	0
0.003	0.015	0
0.003	0.003	0
0.003	0	0
0.003	0.046	0
Average: 0.004	Average: 0.015	Average: 0

TABLE C-32. RESULTS OF AUGUST 14, 1991, AIR MONITORING AT SITE N

Airborne asbestos concentration, s/cm^3		
Previously abated area	Perimeter area	Outdoors
0	0	0
0	0	0
0	0.005	0.009
0	0.005	0.006
0.013	0	0
Average: 0.003	Average: 0.002	Average: 0.003

TABLE C-33. SUMMARY OF BULK SAMPLE RESULTS SITES K AND N REINSPECTION

1988 Abatement Area		
Dust samples:		
Carpentry loft	Duct grill	Negative
Carpentry shop	North Nesbitt heater	Positive[a], amosite asbestos Positive, chrysotile asbestos
Carpentry shop	South Nesbitt heater	Positive, chrysotile asbestos
Carpentry shop	Table saw motor box	Positive, chrysotile asbestos
Carpentry shop	Window ledge, north	Positive, chrysotile asbestos Positive, amosite asbestos
Carpentry shop	Window ledge, north	Positive, chrysotile asbestos Positive, amosite asbestos
Bulk samples:		
Carpentry shop	Spray-on ceiling material	Negative
Carpentry classroom	Dust, top of ceiling	Negative
Carpentry shop	Roofing felt	Negative
Carpentry shop	Spray flakes, window ledge	Negative
Carpentry shop	Roof shingles (display)	Negative
Carpentry shop	Ceiling tile	Negative
Carpentry shop classroom	Floor tile	7% Chrysotile asbestos
Carpentry shop	Sheetrock (display)	Trace[b], chrysotile asbestos
1988 Perimeter Area		
Hall outside carpentry shop	Ceiling tile	Negative
Special education	Sheetrock (stored)	Negative
Exterior storage	Mason's sand	Negative

[a] This classification was defined by the NJDOH laboratory to accommodate samples of which there is not adequate material available to allow a full quantitative evaluation, but are of sufficient size to determine that asbestos is present and to determine the specific type of asbestos. Based on the professional judgement of the analyst, the sample is considered to contain greater than 1% asbestos.

[b] Trace = <1% asbestos

1988 Perimeter Areas

Hallway and Miscellaneous Classrooms

Samples of building materials did not show detectable levels of asbestos. No apparent source of the asbestos-containing material was identified.

Conclusions

Although asbestos-containing dust was present on surfaces in the carpentry shop, no apparent sources of asbestos associated with the 1988 abatement could be identified in this area or in other perimeter areas.

Asbestos materials in the brake and clutch assemblies in various high speed equipment could be a possible source of elevated levels. The misidentification of VAT in the management plan could also lead to uncontained VAT removals, improper O&M and possible contamination.

APPENDIX D

AVERAGE AIRBORNE ASBESTOS CONCENTRATIONS MEASURED IN 1988, 1990, AND 1991

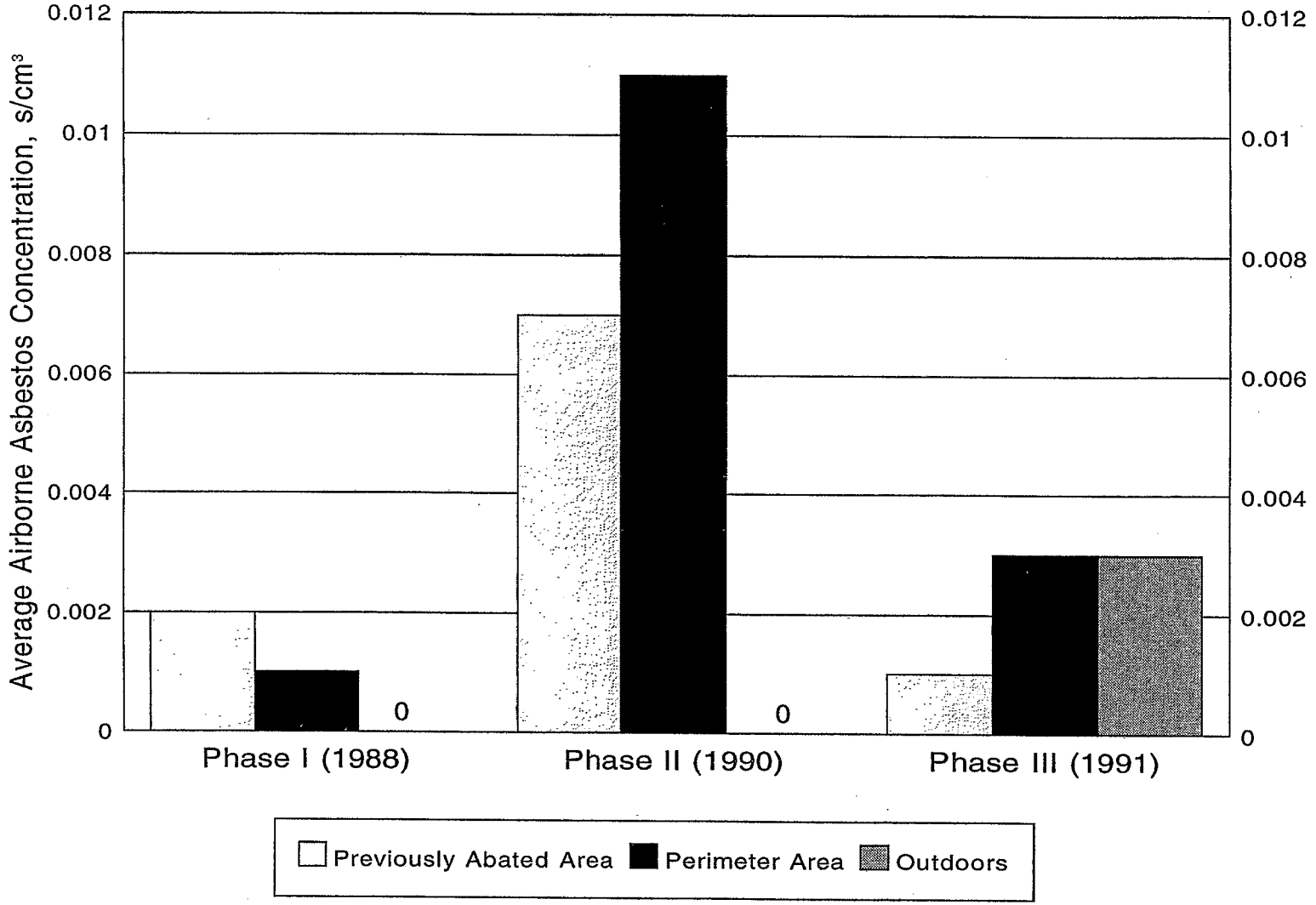

Figure D-1. Comparison of average airborne asbestos concentrations measured at Site A in 1988, 1990, and May 1991.

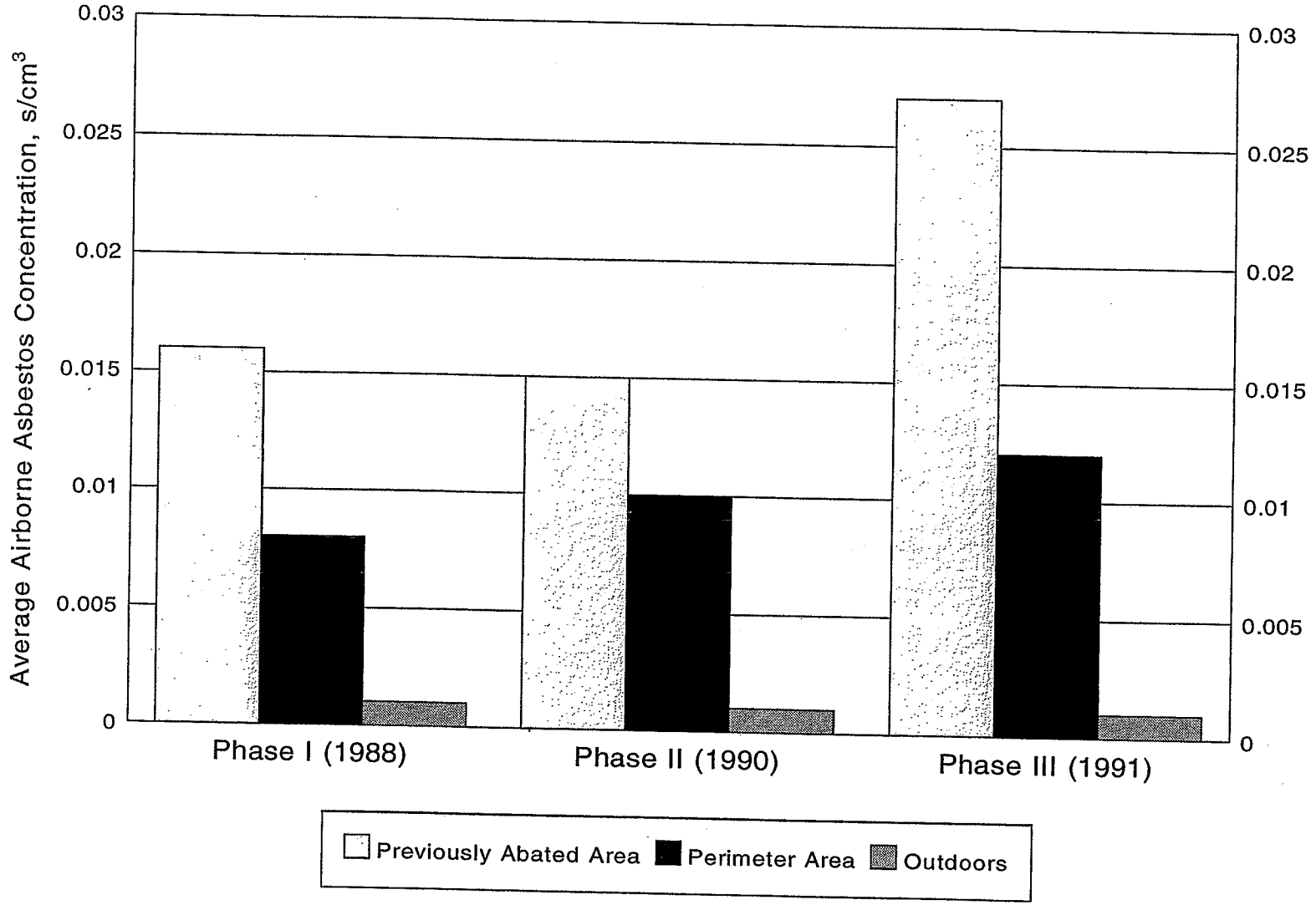

Figure D-2. Comparison of average airborne asbestos concentrations measured at Site B in 1988, 1990, and May 1991.

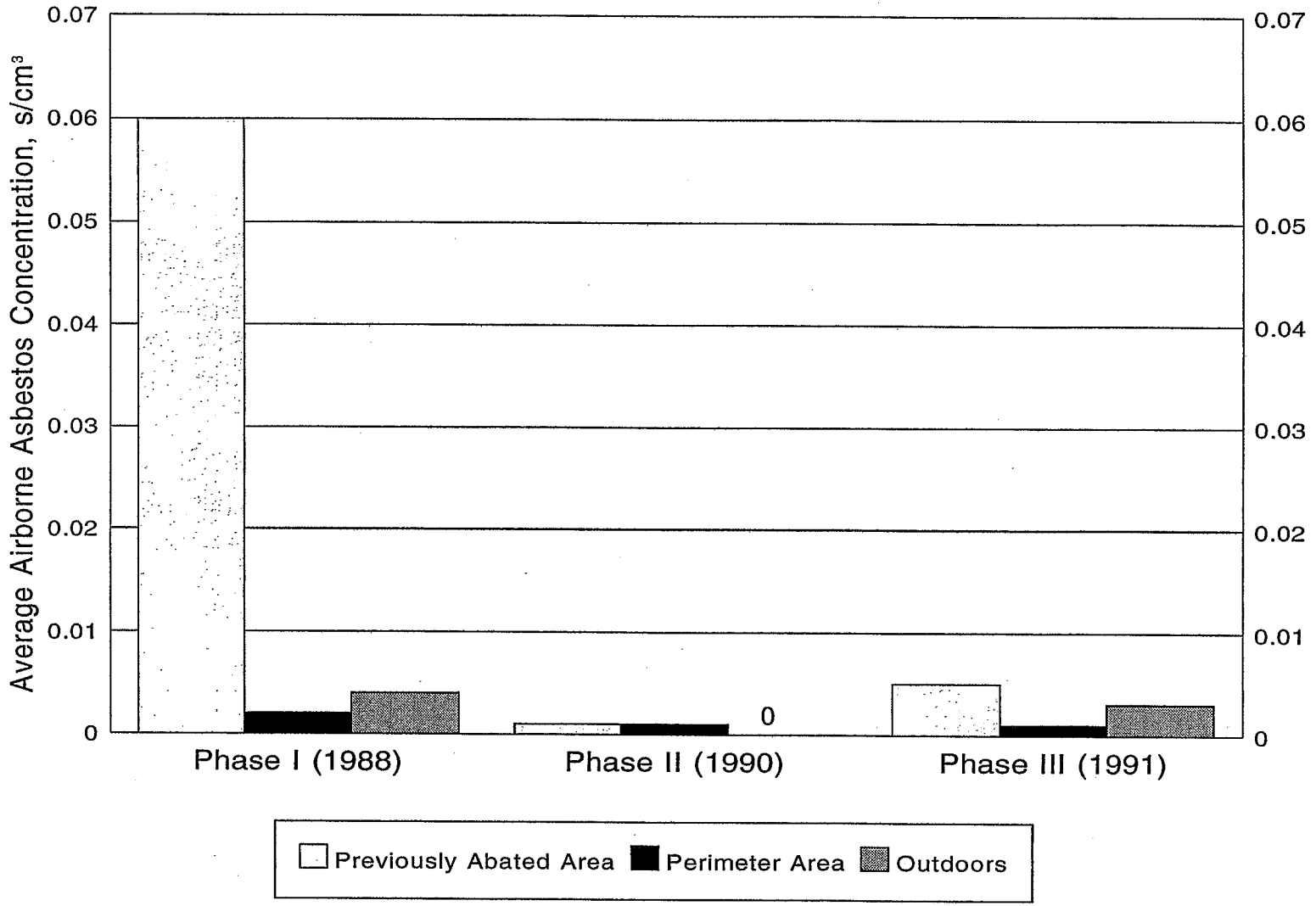

Figure D-3. Comparison of average airborne asbestos concentrations measured at Site C in 1988, 1990, and May 1991.

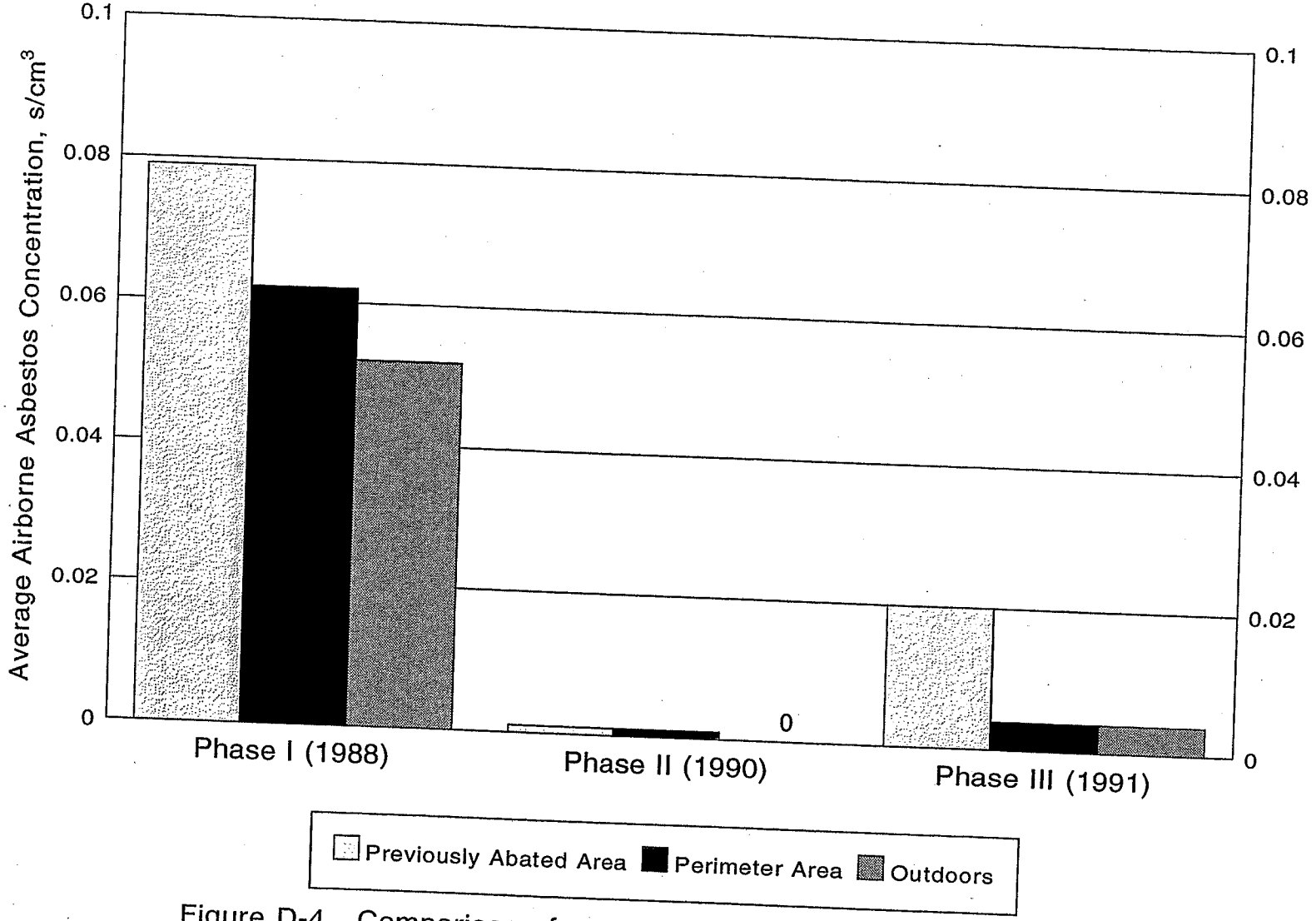

Figure D-4. Comparison of average airborne asbestos concentrations measured at Site D in 1988, 1990, and April 1991.

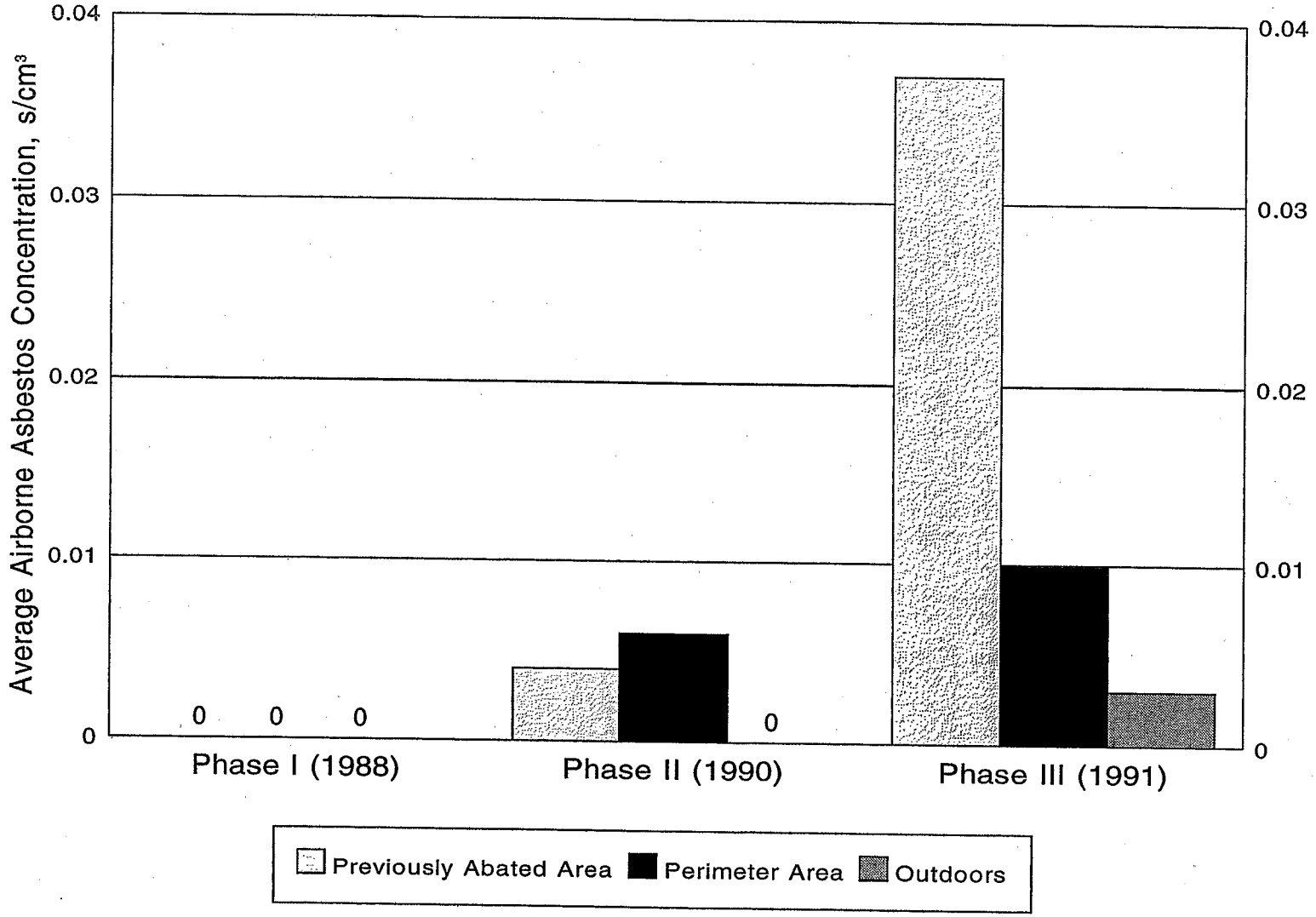

Figure D-5. Comparison of average airborne asbestos concentrations measured at Site E in 1988, 1990, and May 1991.

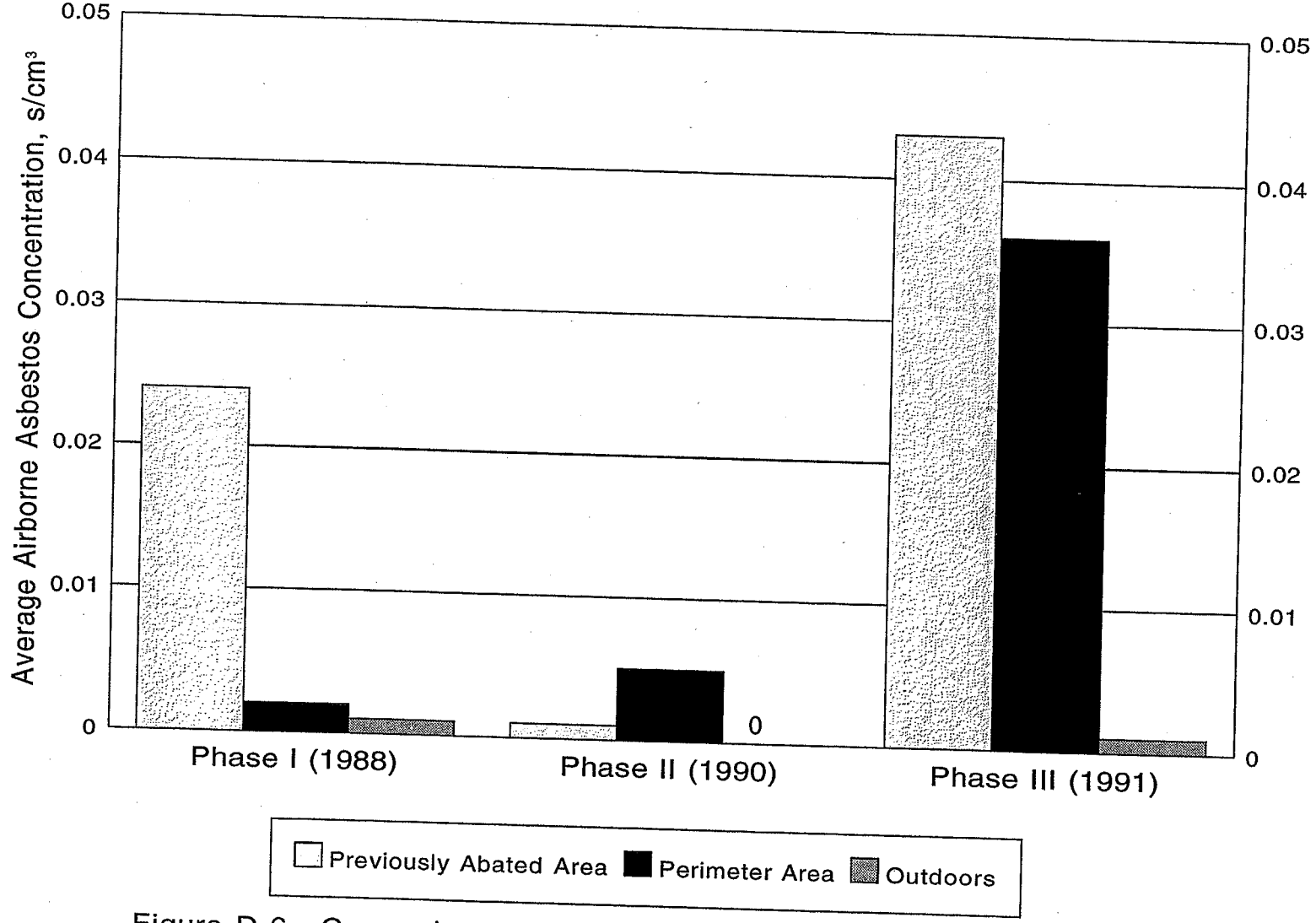

Figure D-6. Comparison of average airborne asbestos concentrations measured at Site F in 1988, 1990, and May 1991.

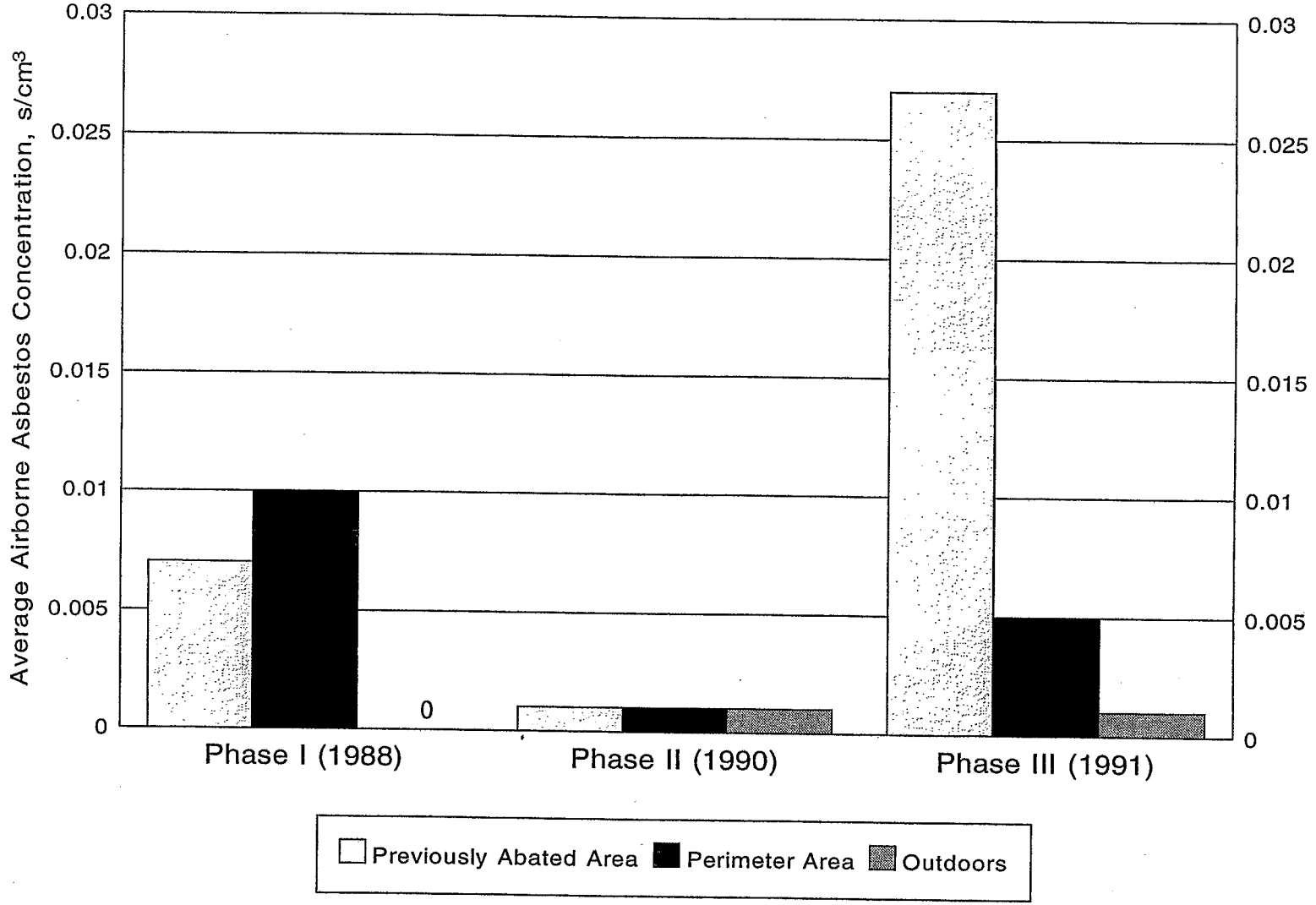

Figure D-7. Comparison of average airborne asbestos concentrations measured at Site G in 1988, 1990, and May 1991.

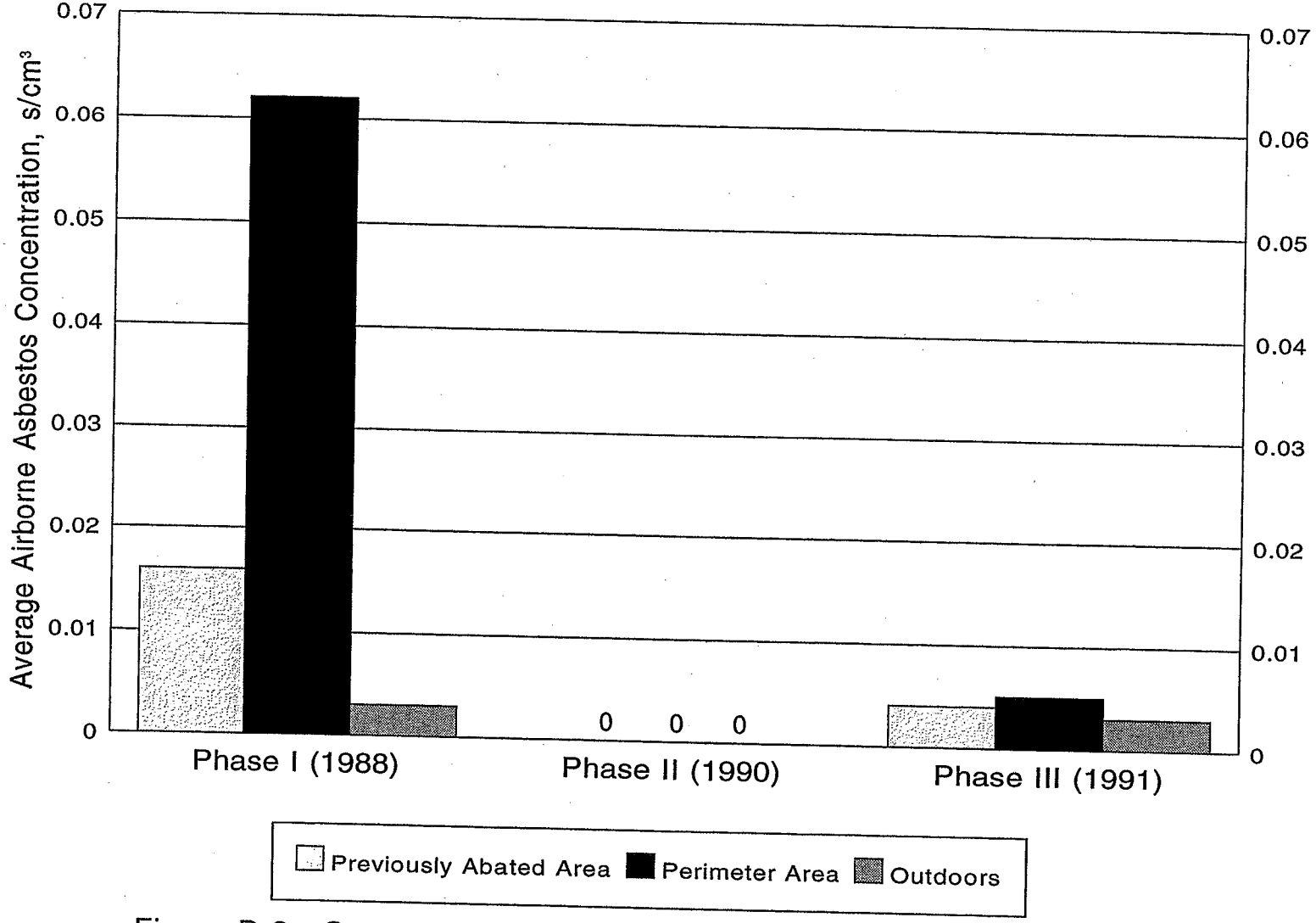

Figure D-8. Comparison of average airborne asbestos concentrations measured at Site H in 1988, 1990, and April 1991.

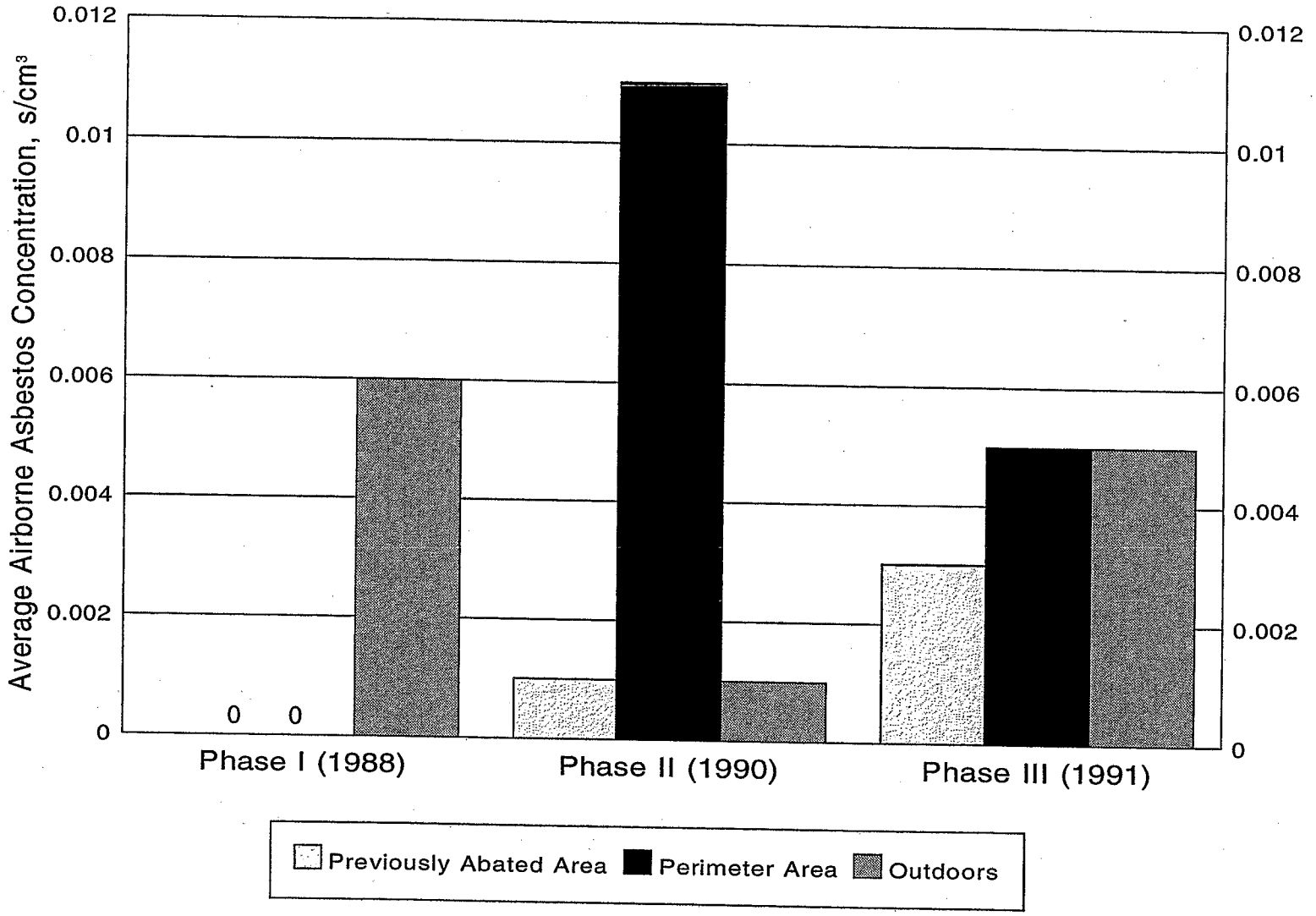

Figure D-9. Comparison of average airborne asbestos concentrations measured at Site I in 1988, 1990, and May 1991.

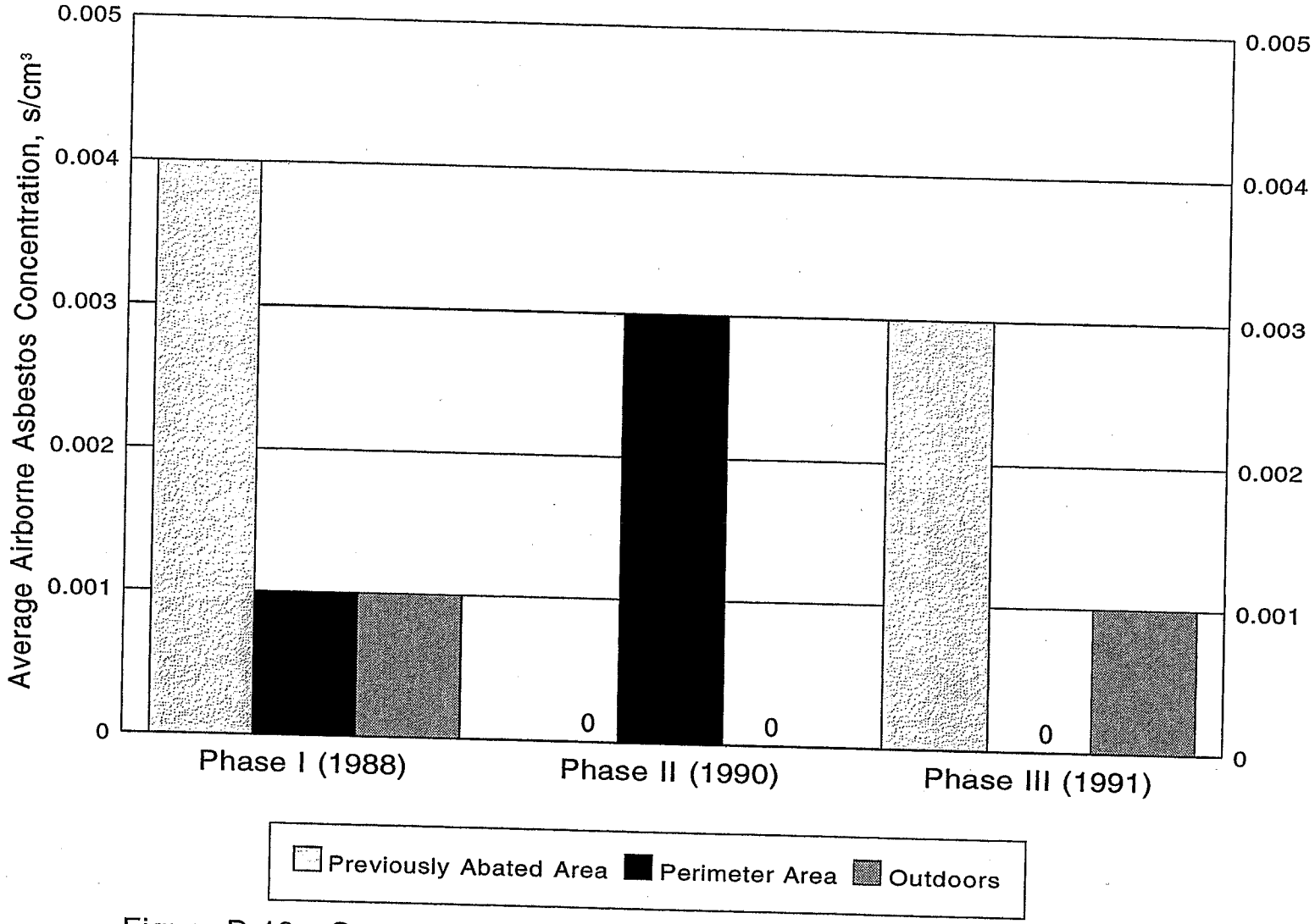

Figure D-10. Comparison of average airborne asbestos concentrations measured at Site J in 1988, 1990, and May 1991.

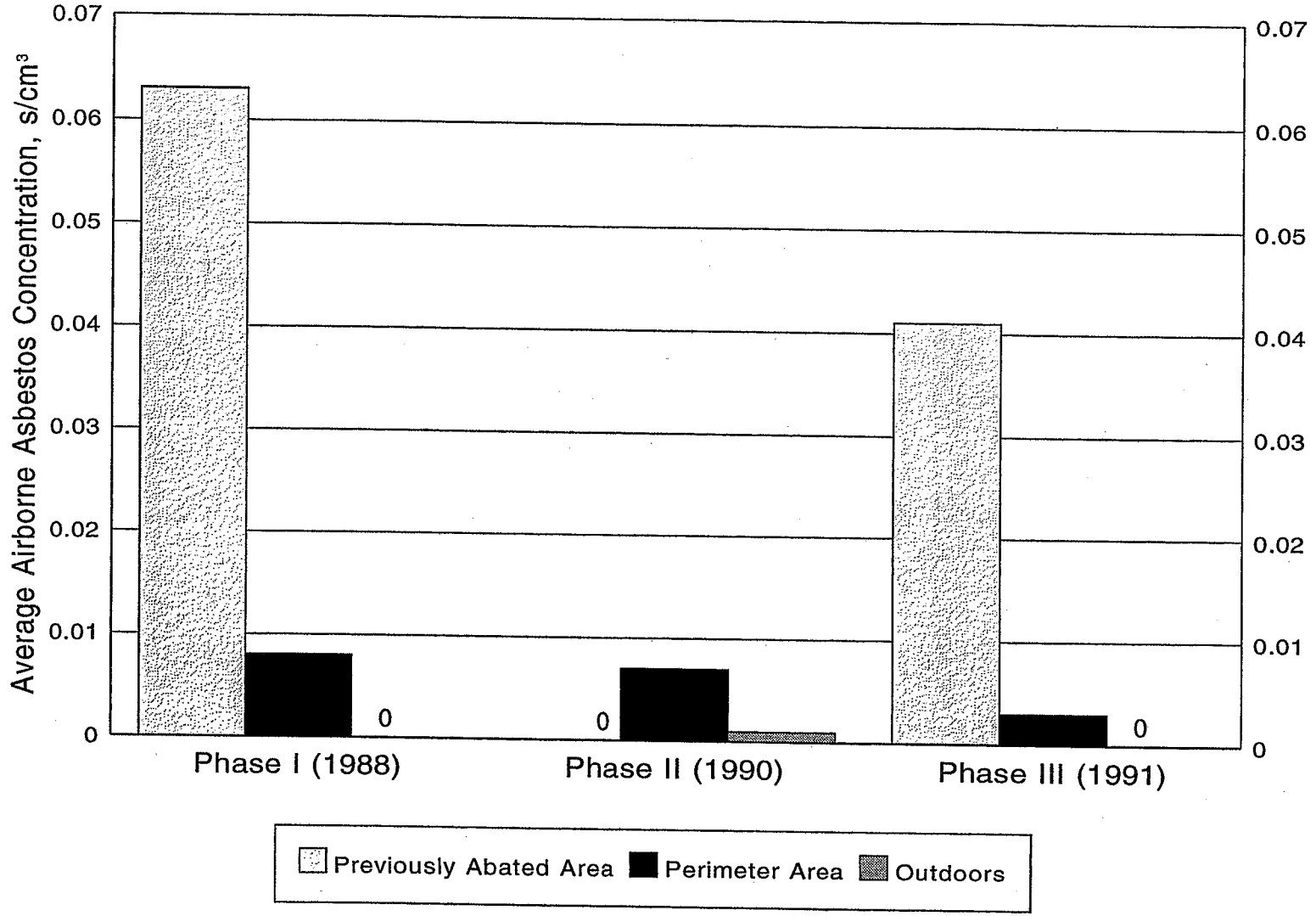

Figure D-11. Comparison of average airborne asbestos concentrations measured at Site K in 1988, 1990, and April 1991.

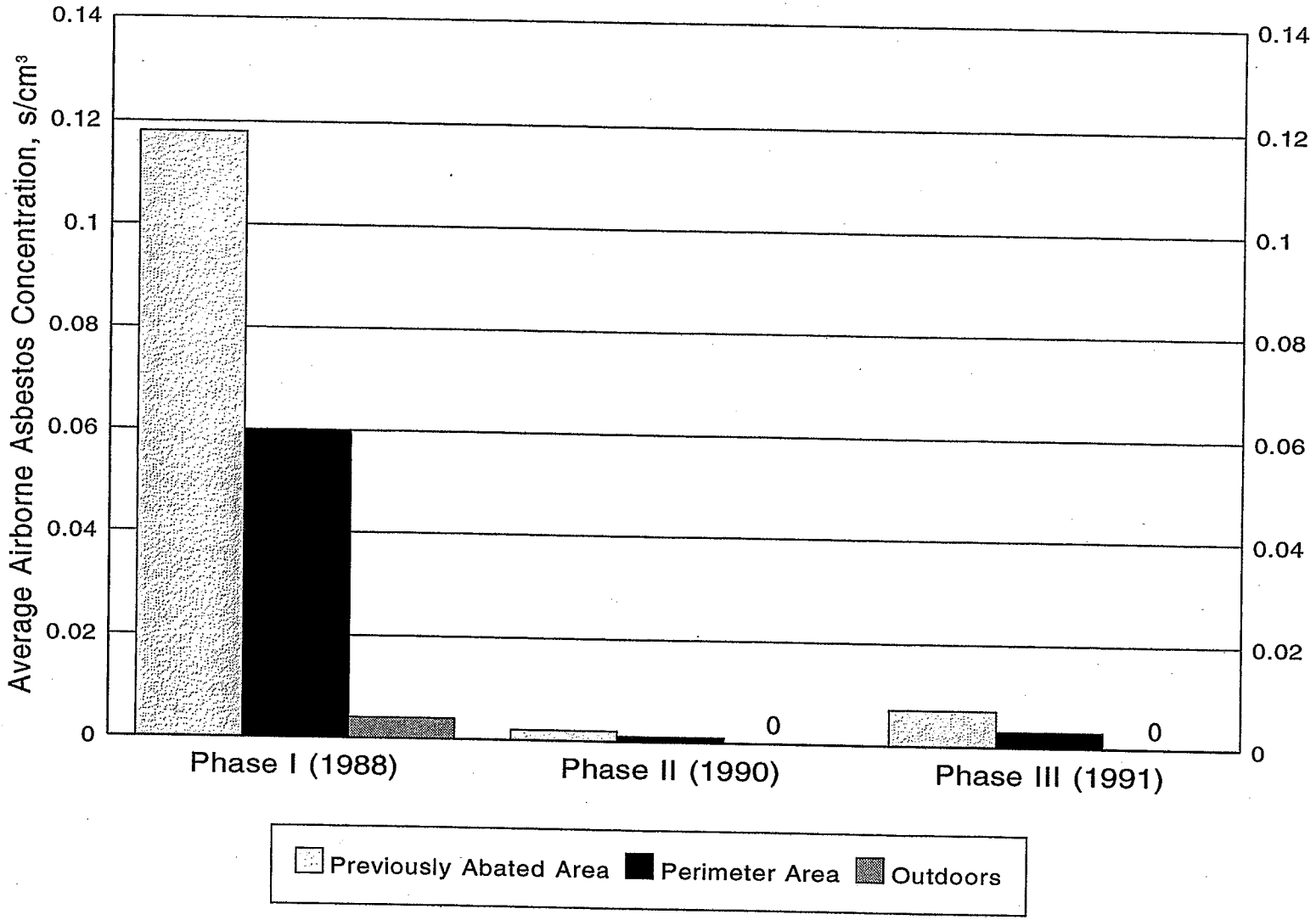

Figure D-12. Comparison of average airborne asbestos concentrations measured at Site L in 1988, 1990, and May 1991.

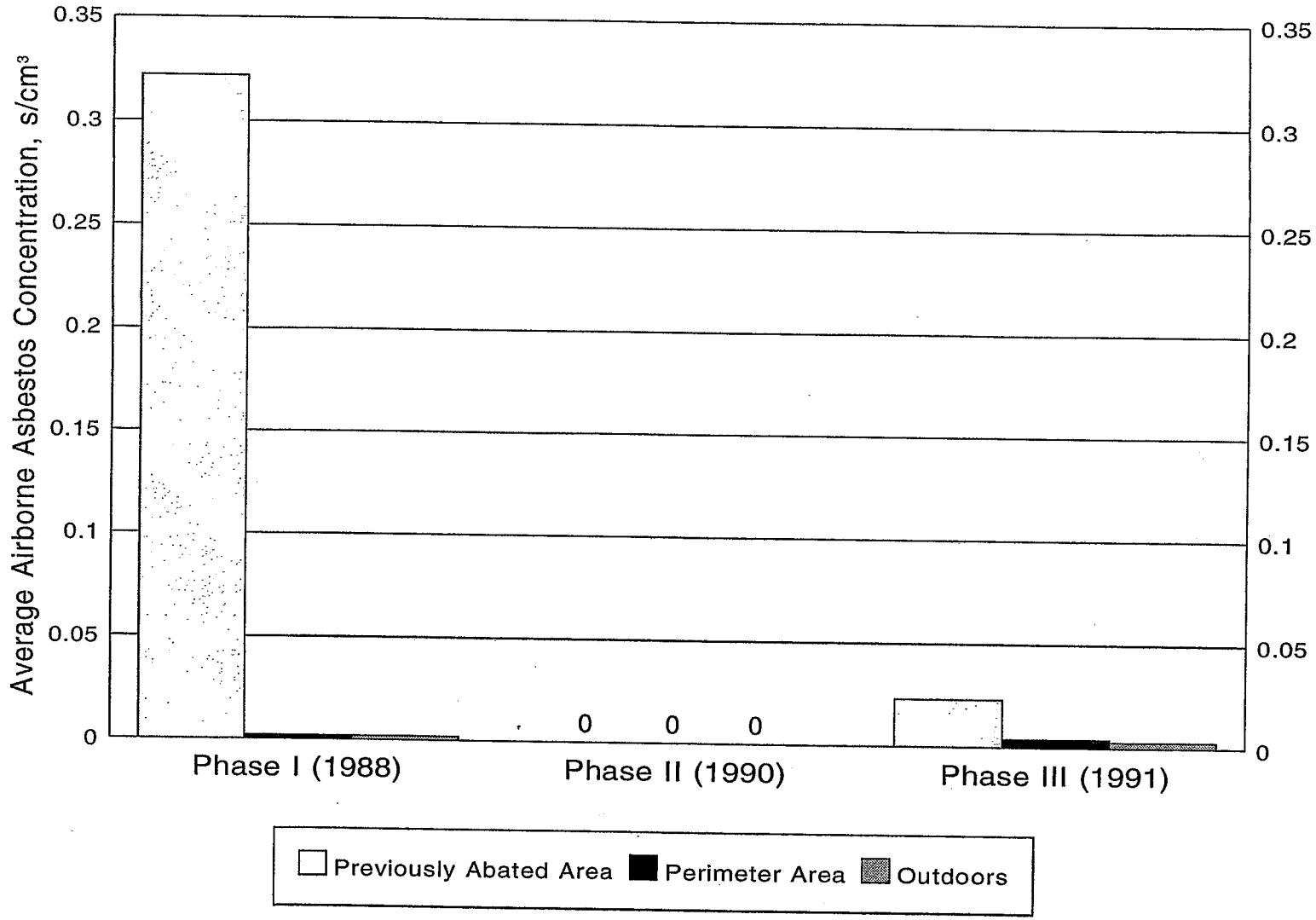

Figure D-13. Comparison of average airborne asbestos concentrations measured at Site M in 1988, 1990, and May 1991.

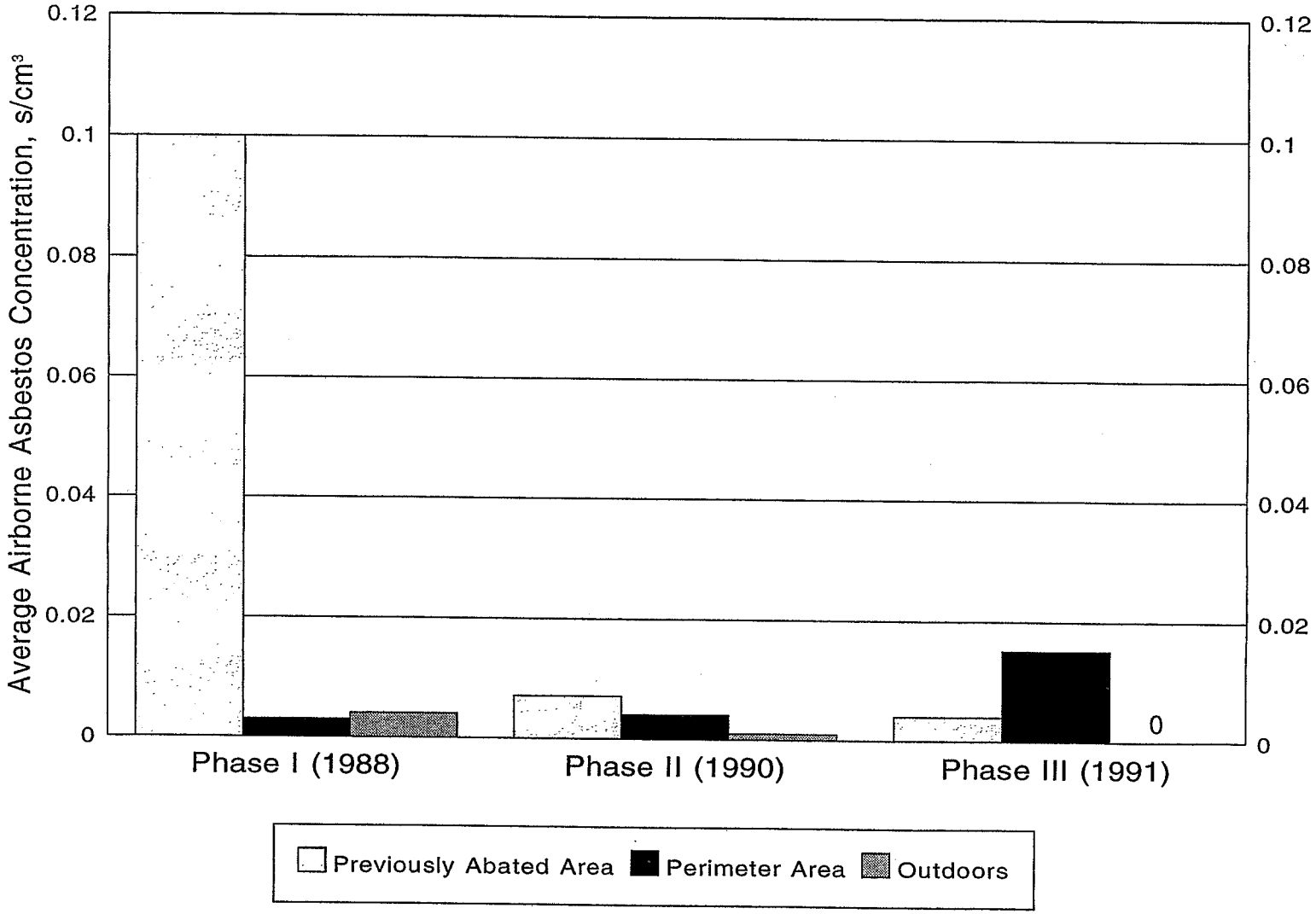

Figure D-14. Comparison of average airborne asbestos concentrations measured at Site N in 1988, 1990, and April 1991.

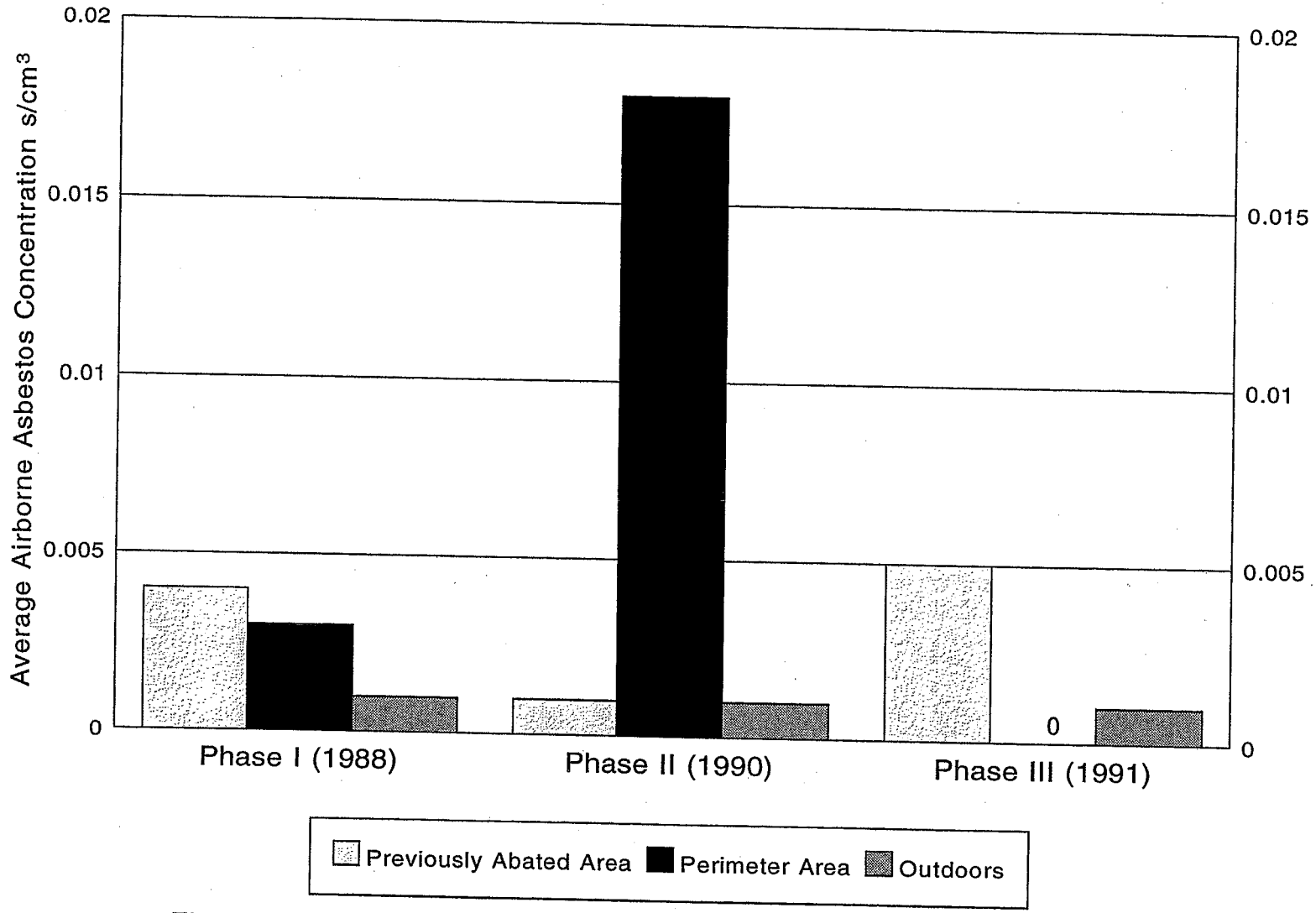

Figure D-15. Comparison of average airborne asbestos concentrations measured at Site O in 1988, 1990, and May 1991.

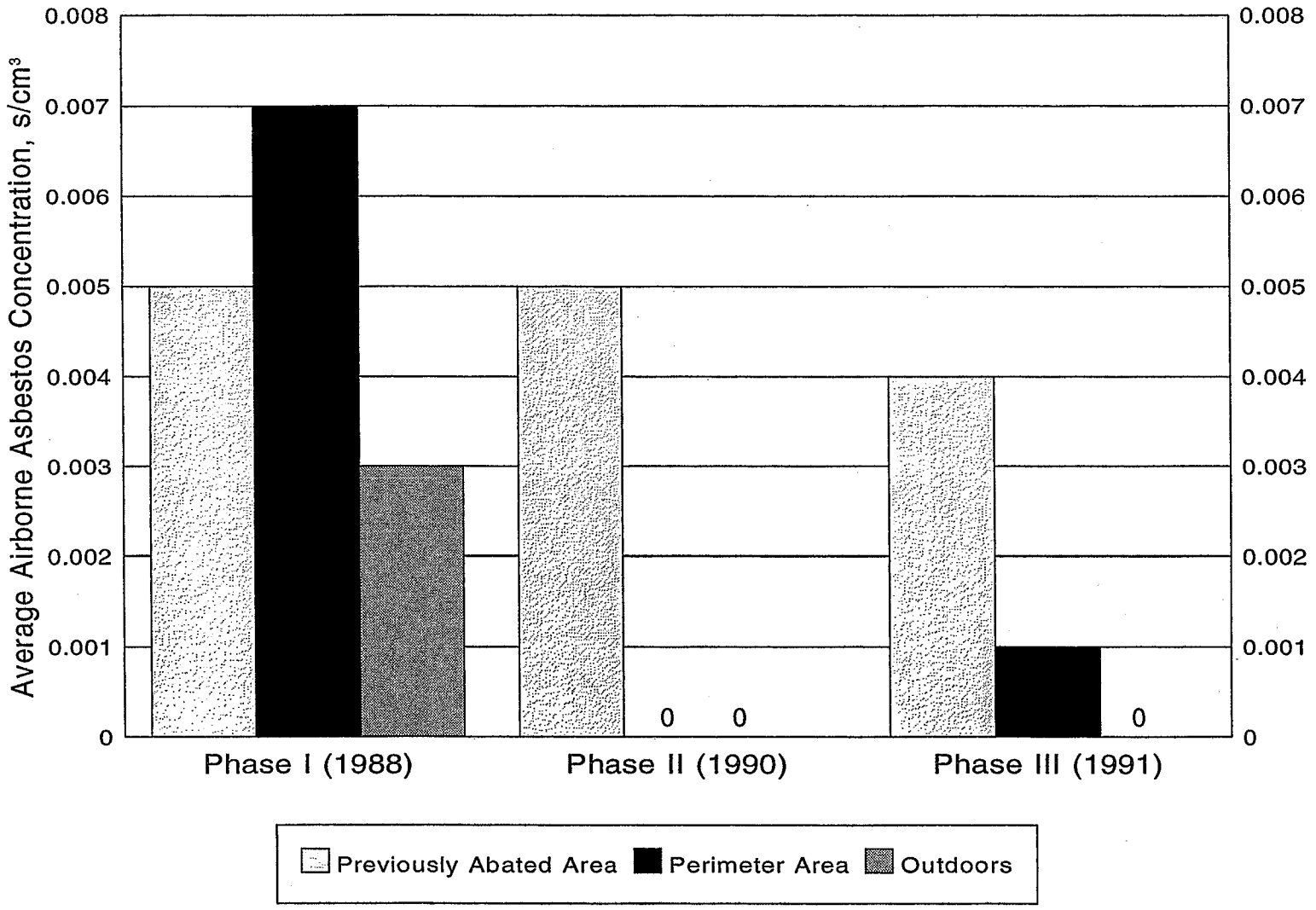

Figure D-16. Comparison of average airborne asbestos concentrations measured at Site P in 1988, 1990, and May 1991.

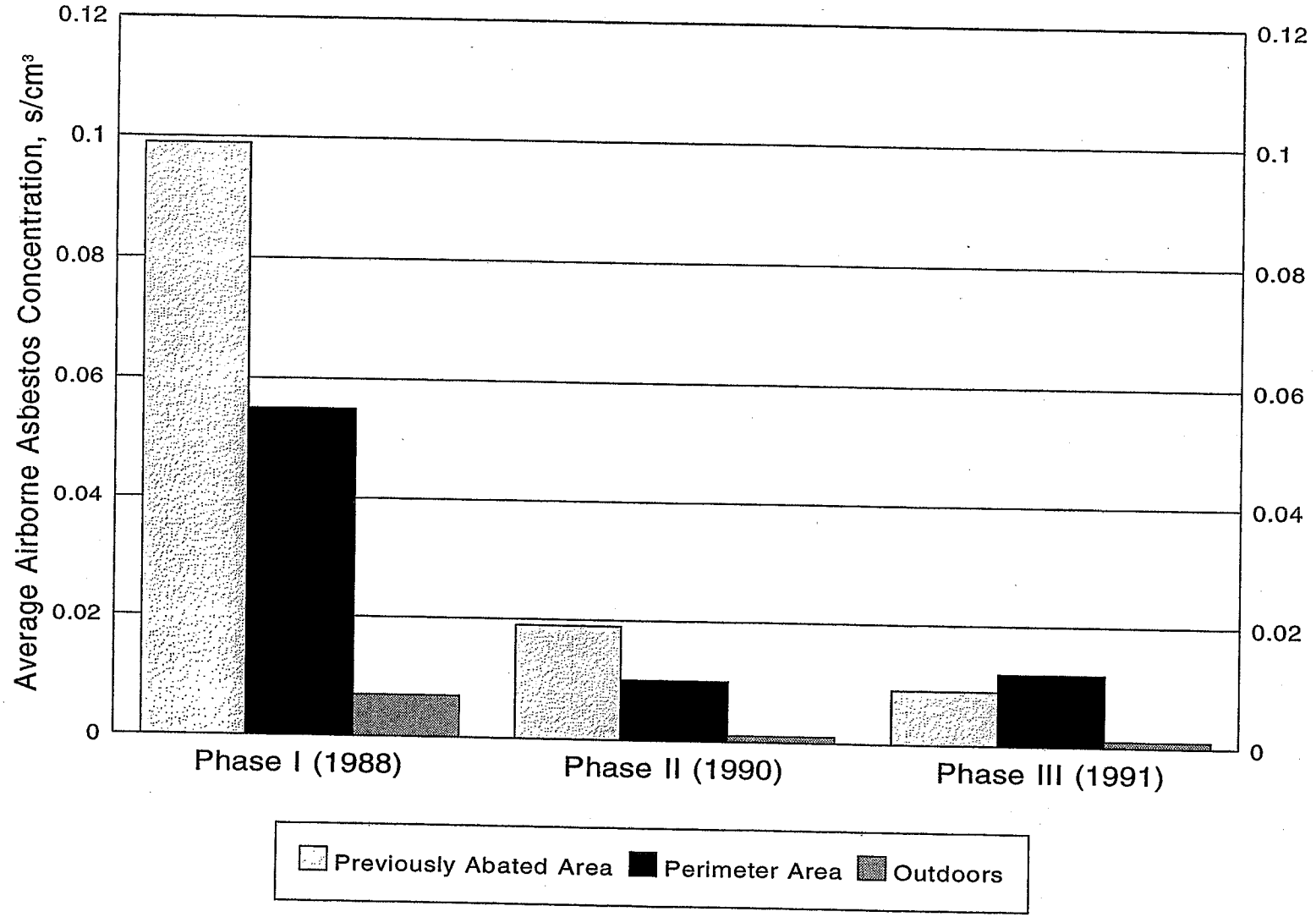

Figure D-17. Comparison of average airborne asbestos concentrations measured at Site Q in 1988, 1990, and May 1991.

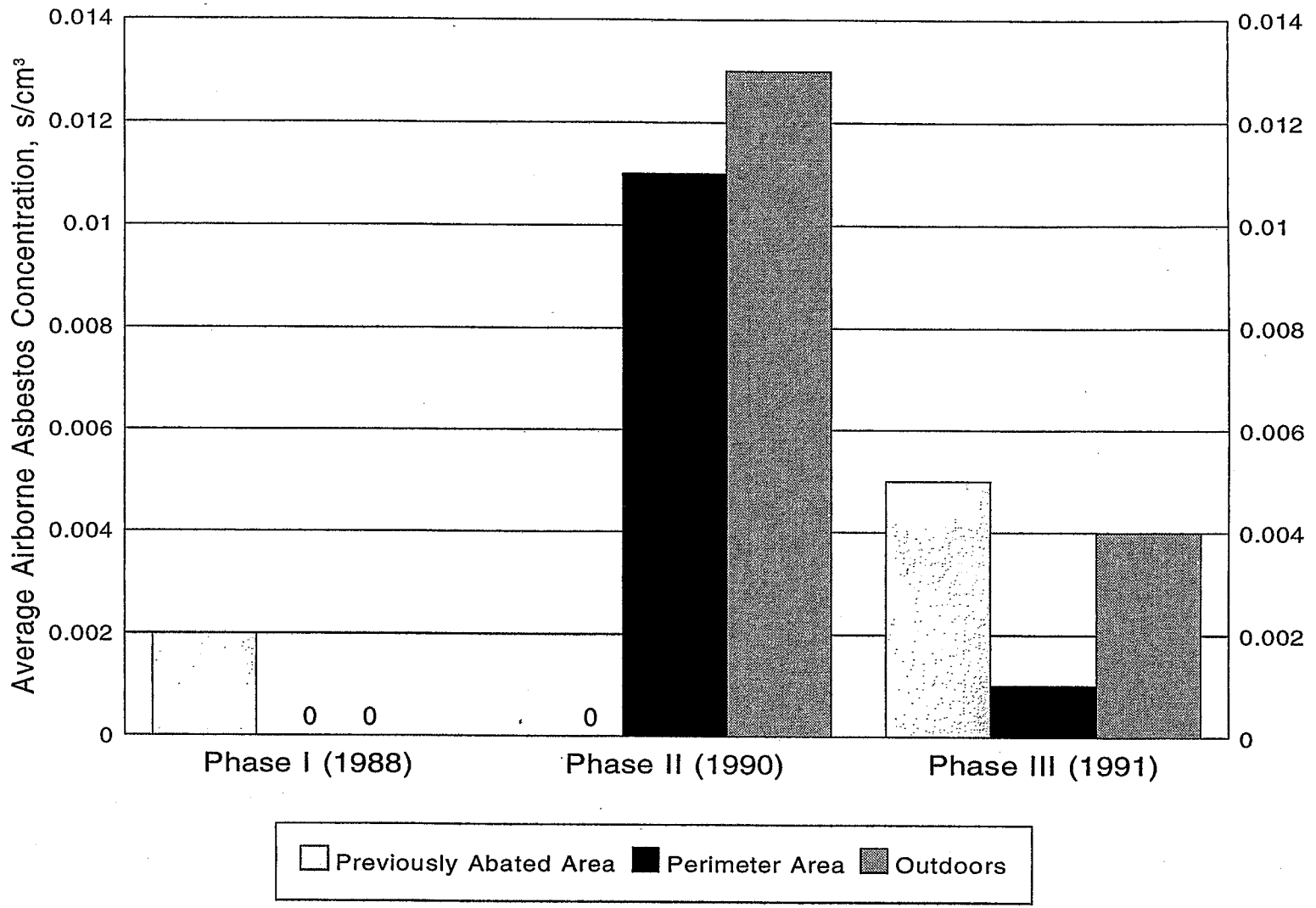

Figure D-18. Comparison of average airborne asbestos concentrations measured at Site R in 1988, 1990, and May 1991.

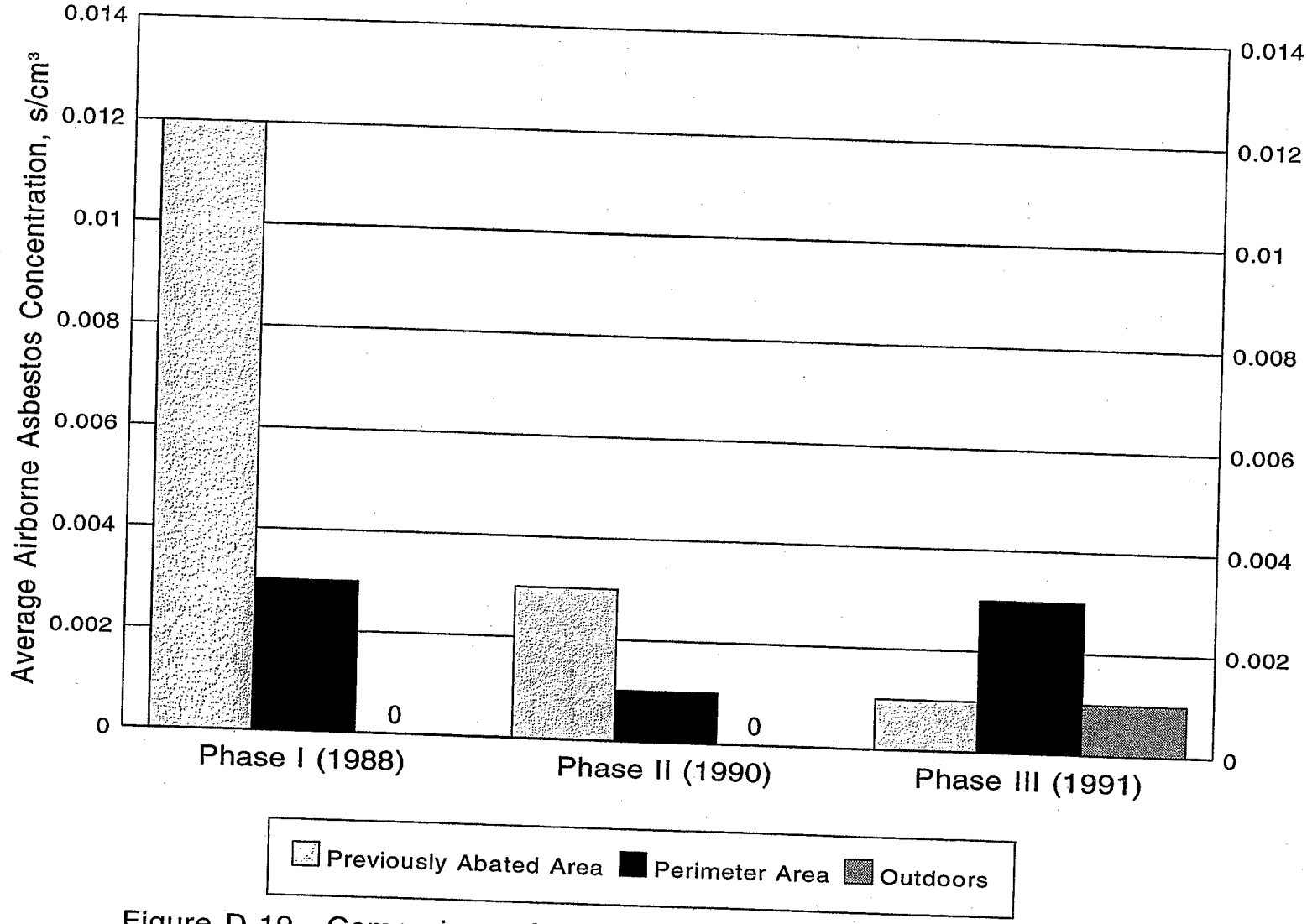

Figure D-19. Comparison of average airborne asbestos concentrations measured at Site S in 1988, 1990, and May 1991.

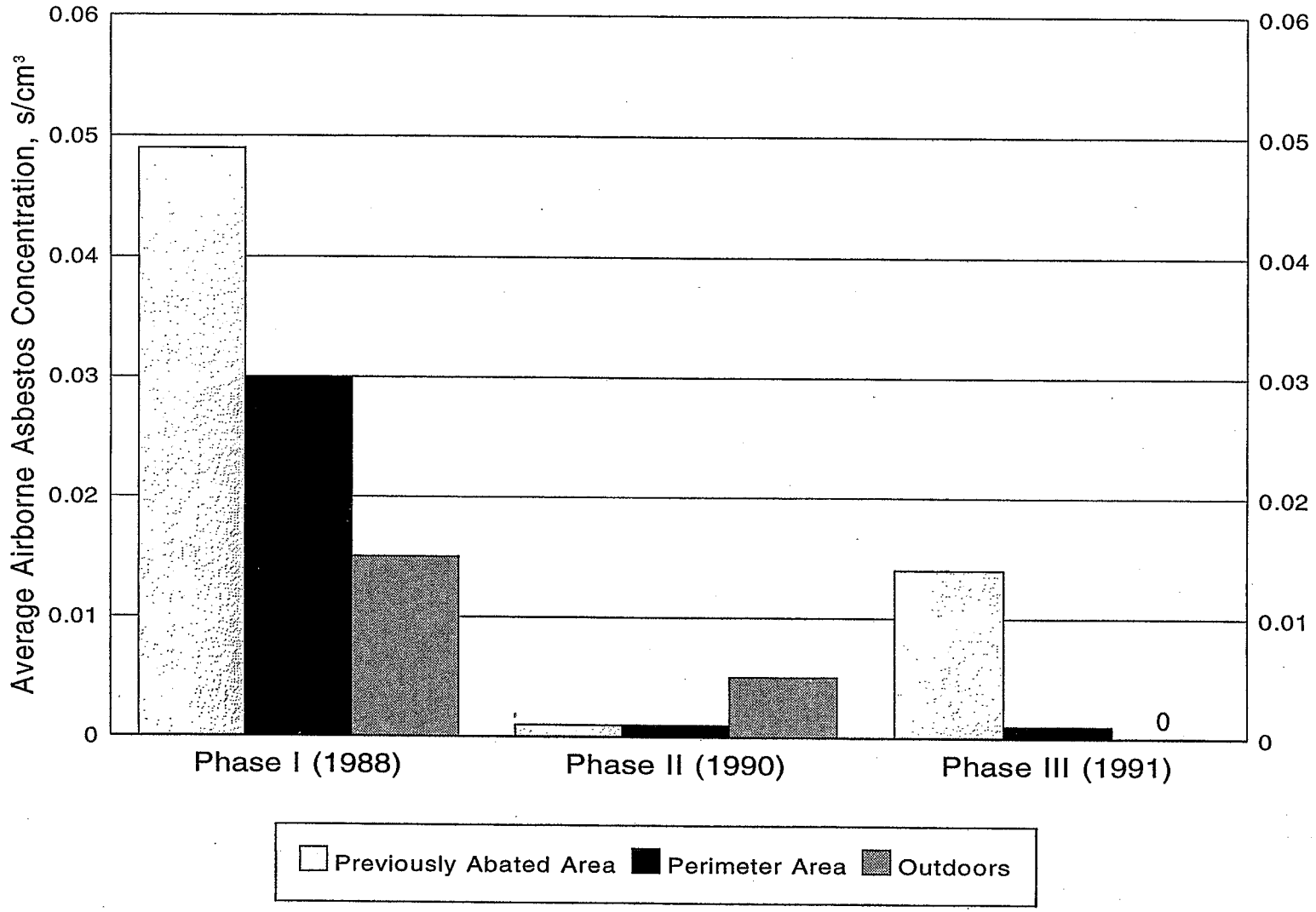

Figure D-20. Comparison of average airborne asbestos concentrations measured at Site T in 1988, 1990, and May 1991.